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EDITORIAL NOTES.

THOSE of our readers who have decided to attend the Congrès Géologique International in Brussels this August may be interested to learn that the Geologists' Association published last summer in connexion with their Excursion to Belgium a separate pamphlet on the "Geology of Belgium". Copies may still be obtained through Messrs. Edward Stanford, Ltd., 12–14 Long Acre, W.C., at the price of 3*s.* 6*d.* The pamphlet contains a copy of the coloured geological map issued by the Belgian Government, and figures illustrating a diagrammatic section across Belgium, the great Devonian transgression, the mode of occurrence of Coral Reefs in the Devonian of the Ardennes, and several other features. The following is a list of the contents :—

Outline Sketch of the Geology in the light of recent research. Dr. L. Dudley Stamp.
The Palæozoic Formations of the southern part of the Dinant Basin. M. Eug. Maillieux.
The Carboniferous Limestone. Professor G. Delépine.
The Coal Measures. Dr. P. Pruvost.
The Cretaceous and Tertiary Formations of the Mons district. Professor J. Cornet.
The Tertiary. Dr. L. Dudley Stamp.

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AT the School of Metalliferous Mining, Camborne, Cornwall, a Holiday Course in Economic Geology will be held from 17th July to 26th August, 1922. The course will include lectures, laboratory work, field work, and excursions, two days in each week being spent in the lecture rooms and laboratories, the rest out of doors or underground. The lectures will deal with the principles of Economic Geology, special stress being laid on applications to Cornwall. The fee for the course is six guineas, and excursions by motor will cost about two pounds more. Applications to join should be made before 1st June to the Secretary, School of Mines, Camborne, from whom further particulars and addresses of lodgings can be obtained.

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THE Council of the Royal Astronomical Society has decided to issue special supplements to the *Monthly Notices* containing papers of geophysical interest. Non-members of the Society who wish to receive these supplements are invited to apply as soon as possible to the Assistant Secretary, Royal Astronomical Society, Burlington House, London, W.1, stating whether they desire a regular supply. The price will depend on the number and length of the papers printed, but will not for the present exceed 10*s.* per annum.

ORIGINAL ARTICLES.

On *Dinocochlea ingens*, n.gen.et sp., a gigantic Gastropod from the Wealden Beds near Hastings.

By B. B. Woodward, F.L.S., F.G.S.

(PLATES X AND XI.)

DURING the construction by the Hastings Corporation of a new arterial road to the north of St. Leonards, near Silver Hill, not far from the Old Roar Waterfall, and close to the quarry dubbed by Mantell the "Iguanodon Necropolis", the cutting passed through some sandy beds of the Wadhurst Clay Series. In these there was one particular stratum that had been a pale blue concretionary calciferous sandstone, but which had been altered for the most part by the percolation of water into a rusty-brown ferruginous sandrock.[1] Numerous large, typical concretions occurred in it, but besides these Mr. H. L. Tucker, who was then acting as engineer to the contractors for the work, noticed the presence of certain huge spiral bodies that seemed to differ from the ordinary concretions. These bodies generally lay in cavities, or "moulds" in the surrounding sandstone, but unfortunately no part of these moulds was preserved.

Mr. Tucker called the attention of Mr. A. Belt (Chairman of the Hastings Museum Committee), Mr. W. Ruskin Butterfield (Curator of the Hastings Museum), and others, to these bodies, but no definite conclusion being reached locally concerning their nature, specimens were forwarded to the Natural History Museum, where Dr. A. Smith Woodward, the Keeper of the Geological Department, at once recognized the possibility of their molluscan origin and consequent interest and value. Dr. Woodward very kindly invited me to undertake their description, and has aided in every way in the matter, including the grant of the assistance of his Preparator, Mr. L. E. Parsons, who has been most willing and helpful.

Unfortunately, by the time that the importance of the discovery had been recognized, the destruction of the best specimen, begun by the "shot" that revealed it, had proceeded apace, and much of the material had been dispersed in various ways. Fragments were received from the Hastings Museum, whilst Mr. W. J. Lewis Abbott sent up such portions as were in his possession, with an interesting series of other fossils, etc., from the same horizon, as well as notes on the deposit. Further, we are indebted to Mr. H. T. Pottinger, of Oxford Street, Stepney, for the use of a photograph he took showing the greater part of the principal specimen as it lay where found (Plate X).

That these spiral bodies, some with dextral, others with sinistral twist, are not ordinary, or even abnormal concretions, is shown by the similarity of the specimens and the regularity of their coils. Mineralogical colleagues to whom they have been shown unanimously discard them as concretions. Their horizontal position in the deposit further precludes the possibility of their representing excentric,

[1] See Note by Mr. W. Campbell Smith appended to this article.

DINOCOCHLEA INGENS, WEALDEN, HASTINGS.

[*To face p.* 242.

water-worn cavities subsequently filled up. A minor difference between them and the true concretions in the same deposit, but a noteworthy one, is that while the latter either exfoliate, or split in any direction, the spirals rarely exhibit exfoliation and usually fracture in a plane at right angles to their axis, generally directly through the whorl, but often in a plane more or less coincident with the line of suture between the whorls. The two systems sometimes occur in close proximity, wedge-shaped pieces resulting. Finally, the twist of these bodies, as will be seen later, conforms to the law of the logarithmic spiral, which Canon Moseley and others have shown to be characteristic of the molluscan shell,[1] whilst no known concretion does so.

The conclusion seems, therefore, inevitable that these spiral bodies represent the internal casts of examples of a huge univalve, molluscan shell, some 6 feet and more in length, whose existence has hitherto been unsuspected.

Now the only molluscan shell comparable to this as a concrete whole in size is that of the Carboniferous *Actinoceras giganteum* (Sby.), the length of which was computed by its author to have sometimes exceeded 8 feet, an estimate, however, which possibly did not err on the side of moderation. Recollection of this, and the large size of the protoconch in the new find, naturally raised the question whether it also represented a Cephalopod shell of the Turrilite or *Cochloceras* description. The general facies and the total absence of any trace of septal sutures preclude this idea, quite apart from the difficulty of reconciling the presence of a marine animal in a deposit which only contains fresh- or brackish-water forms. Nor, for similar reasons, as well as on account of bulk, should affinity be sought with some terrestrial form, although the elongate cylindrical shape and many whorls vividly recall *Megaspira*. The recent fresh- or brackish-water mollusca that seem to come nearest to the form in question belong to the Tiaridæ (*olim* Melaniidæ), or such exceptional Cerithiidæ as are known to penetrate into brackish water, notably the Potamidinæ, of which a possible representative has already been recorded from the Wealden.[2]

[1] Moseley (Rev. H.), "On the Geometrical Forms of Turbinated and Discoidal Shells": *Phil. Trans.*, 1838, pp. 351–370. For an able summary of the conclusions by Moseley and others, see Professor D'Arcy W. Thompson's *Growth and Form*, chap. xi, pp. 493–586.

[2] The fossil in question is a cerithoid-like shell about 1½ in. in length, that has been successively referred to:—

Muricites strombiformis, Schlotheim, Petref., i, 1820, p. 144.

Melanopsis ? tricarinata, J. Sowerby (Ann. Phil., N.S. viii, 1824, p. 376, as *Melania tricarinata* [n. nud.] and) *Trans. Geol. Soc.*, Ser. II, vol. iv, 1836, p. 346, pl. xxii, f. 4.

Potamides carbonarius, A. Roemer, Nordd. Oolith., 1836, p. 141, pl. xi, f. 17.

Pleuroceras strombiforme, Schloth.: Sandberger, Land- u. Süssw. Conch. Vorwelt, p. 55, 1870, pl. ii, f. 11 *a–g*.

The genus *Muricites*, founded by J. Gesner in 1752 (*Tract. Petr.*, p. 34), is pre-Linnean, and though the name appears again in the second edition of his book in 1758 (p. 56), that does not by present ruling render the name valid.

To put the whole matter to the test, careful measurements were taken of the portions known to belong to the dextral specimen photographed by Mr. Pottinger. The result went to show that they were in accord with a logarithmic spiral having the ratio of 1·02. A diagram (Fig. 1) was then constructed on this basis, the theoretical widths of the successive whorls being calculated by slide rule, the corresponding actual specimens were then allocated to their places and the diameters of the whorls necessarily taken from them. The figures opposite the left of each whorl in the diagram are the calculated measurements, the measurements and the diameters of actual specimens being shown on the right. As was to be expected, these last do not always exhibit mathematical regularity, as, for instance, in the case of the fifteenth to twentieth whorls, but when the totals are cast up of the theoretical and actual measurements they amount to 56·5 cm. and 56·2 cm. respectively, a difference of only 3 mm., showing that in nature what is lost in one whorl is gained in the next, thus restoring the balance of the whole.

The sinistral spiral, although a complete apex of six whorls was present, was less easy to determine owing to the lack of satisfactory additional material. Taking the width of the sixth whorl, however, at 6·5 cm. and calculating both ways from that, what material there was pretty closely corresponded to a ratio of 1·055, and on these lines a corresponding diagram was constructed. There is nothing to show in this case what may have been the total length, but we believe that the eleventh (with parts of the tenth and twelfth) and the thirteenth to fifteenth whorls are represented. The portion of another specimen, the last found, exhibits some five or six whorls, of which the last two are imbedded in the concretionary mass to which it was attached. Three of these, much distorted in fossilization, were measurable and the results yielded were rather remarkable, for taking the widths of each whorl at diametrically opposite points (*A* and *B*) in centimetres the following table originated :—

A	*B*	*Average width.*	*Calculated width of whorls* 14-16.
8·5	11·7	10·1	9·98
10·4	10·9	10·6	10·06
9·4	11·7	10·5	11·18
	Total	31·2	31·22

What the *strombiformis* of Schlotheim may have been cannot be guessed by the description given.

The later ascriptions to recent genera, which the fossil in no wise resembles, are to say the least unfortunate. Especially the last, for *Pleurocera* of Rafinesque is a North American genus, whilst Sandberger's miscorrection of the name to *Pleuroceras* makes confusion with Hyatt's genus of Ammonites.

Sowerby's trivial name may possibly prove valid for the British examples, but a new generic name is desirable.

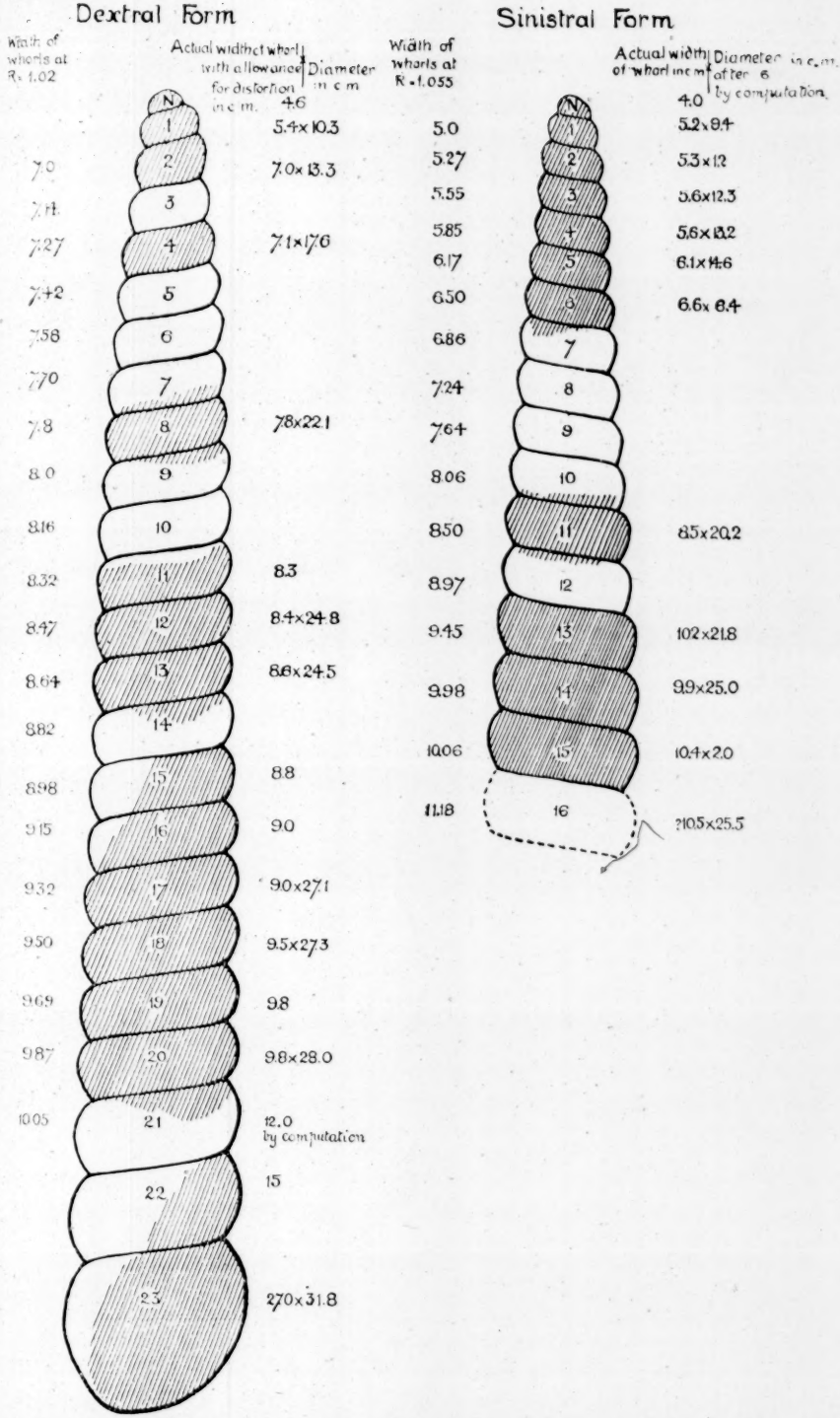

FIG. 1.—Diagrammatic reconstructions of dextral and part of sinistral form of *Dinocochlea ingens*, B. B. Woodw.

This, to say the least, is suggestive that here is another case of irregularity compensated for in the total.

The outcome of this plotting went to show that whereas at first sight the body-whorl appeared to be proportionately much larger than the preceding ones present, and consequently to indicate Cerithoid affinities, the actual fact when the missing portion was restored showed no such great discordance and consequently suggested that relationship lay rather with the Tiaridæ. No member of this family exhibits anything approaching the column-like form of the Wealden giant, but some species of the type genus are proportionately extremely elongate and many-whorled and often carinate above the periphery. There are faint indications that the fossil here described was similarly carinate just above the periphery. Both the Potamidinæ and the Tiaridæ have comparatively thin shells, while their inner structure is often thinner than their exterior would lead one to suspect.

If the foregoing conclusions be correct, as we believe, many interesting questions naturally arise. How could this colossus of its class have thus suddenly appeared and again disappeared, unforecast, and without descendants? What did it feed on, and what preyed on it? Such questions cannot at present be answered, but anyhow a fossil of such importance as this merits a name and such description as the material to hand renders possible. Hence we would propose to designate it:—

DINOCOCHLEA INGENS, n.gen.et sp.[1]

Shell (at present represented only by its cast) dextral or sinistral, elongate cylindrical; whorls, about twenty-three in number, increasing very slowly in size from the apex to the penultimate, and slightly more rapidly in the last and the body whorl; faintly carinate just above the periphery. External characters, aperture and operculum unknown.

Formation and locality.—Wadhurst Clay (Wealden), near Hastings, Sussex.

Dimensions (approximate, taken from the dextral specimen).—Alt. 222 cm. (= *circa* 7 ft. 3 in.); diam., first whorl 10·3, second whorl 13·3, twentieth whorl 28, body-whorl 32 cm. On a rough calculation, the shell tube if uncoiled must have been over 60 ft. in length.

The shell was evidently proportionately very thin, as in some of the recent Tiaridæ, so that on its dissolution the ponderous cast, while yet in a plastic state, shrank on itself, obliterating for the most part the interval which should have been left between the successive whorls and by the columella, a phenomenon also observable in some of the seams of casts of *Viviparus* shells belonging to the same horizon.

[1] As usual in these cases, the generic includes, and should be taken as, the specific description as well.

Specimens present.—Of the dextral form the principal individual is represented by the apex, consisting of the nuclear and first and second whorls; a portion of the fourth (?); part of the seventh with the eighth and part of the ninth; the eleventh, twelfth, and thirteenth, with a part of the fourteenth; part of the fifteenth, most of the sixteenth, and the whole of the seventeenth to twentieth, with part of the twenty-first; the penultimate (? twenty-second) and body-whorl. There are four sets of two or three whorls each that do not accord with the foregoing, or each other, and may be taken to represent portions of other individuals, especially since in some of them the whorls are distinctly less convex. Several whorls (one more convex), or fragments of whorls, are also present.

Of the sinistral form there is an apex, consisting of the nuclear, the first six whorls and part of the seventh, with portions of what probably are the tenth to the twelfth and the thirteenth to fifteenth whorls of the same specimen; there is also a surface portion of a further group of three whorls of very irregular widths, which might correspond to the thirteenth to fifteenth whorls of another individual; and finally a big example of three or four whorls (already alluded to) attached to a concretionary mass of rock, in which the presence of yet two other whorls is traceable, and probably coming somewhere about the twelfth to sixteenth whorls of a distinct individual.

Notes on the Nature of the Containing Rocks.

By W. Campbell Smith, M.C., Sec.G.S., of the British Museum (Natural History).

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The "bluestone" which is found in the central parts of some of the concretions associated with the large spiral bodies described by Mr. B. B. Woodward is found, on microscopical examination, to be a calcareous sandstone. Subangular grains of quartz, averaging 0·04 mm. in diameter, constitute over 50 per cent of the rock, and are set in a cement of carbonates which have crystallized in plates very much as in the Fontainebleau sandstone. These plates are sometimes 3 cm. across, and give a characteristic lustre to the stone. The quartz-grains are evenly distributed through the plates of crystalline carbonate, and are so closely packed as to be almost in contact. It is easy to imagine that with the complete removal of the carbonates by solution there would remain a friable sandstone, very porous, but still occupying almost the same volume as the bluestone.

In the bluestone 35·6 per cent of the rock is soluble in dilute hydrochloric acid, and contains 17·82 per cent CaO, corresponding to 31·82 per cent calcium carbonate, and 2·58 per cent Fe_2O_3, probably present as 3·74 per cent of $FeCO_3$. Insoluble material consists of about 61 per cent quartz and 3 per cent insoluble silicates. The density of the rock is 2·62, very slightly less than the density calculated from its components (2·72), showing that the pore-space in the bluestone is very small indeed.

In the sandstone within an inch or two of the blue core there was found only 0·73 per cent CaO corresponding to 1·30 per cent $CaCO_3$, so that this part of the concretion is almost free from calcite cement.

To test the question of whether any change in bulk accompanied the change of bluestone to sandstone the volume of a weighed mass of the dry sandstone was determined by coating the sandstone with a thin waterproofing coat of varnish, and determining its effective density in that condition. Two determinations gave a value for this effective density of 1·9. This approximates very closely to the value one would expect if the whole of the calcite of the bluestone were removed without any change in the volume occupied by the resultant sandstone as is shown by the following calculation :—

The density of the bluestone containing 32 per cent of $CaCO_3$ was determined as 2·62. One hundred grams of bluestone will, therefore, occupy a volume of $\frac{100}{2{\cdot}62} = 38{\cdot}16$ c.c.

The removal of the whole of the 32 per cent $CaCO_3$ will reduce the weight of the rock from 100 to 68 grams.

If this removal is unaccompanied by any change in volume, it will have an effective density of $\frac{68}{38{\cdot}16} = 1{\cdot}8$. The value found for the sandstone is 1·9.

Admittedly this is only a very approximate calculation, but the agreement seems close enough to show that a bluestone of the type forming the inner part of the concretions can lose the whole of its 30 per cent of calcite and give rise to the sandstone of the outer shells without any suffering change in volume and therefore without the disturbance of the outer form of the concretion, or the destruction of any structures within it.

EXPLANATION OF PLATES X AND XI.

Plate X.

Photograph taken by Mr. H. T. Pottinger of the greater part of the principal dextral specimen as it lay where found. The remains of the shattered apex were scattered towards the right ; the body-whorl to the left did not come into the picture.

Plate XI.

A.—Sinistral form :—

FIG.

1, 2, 3.—Associated fragments of one individual, representing whorls 1–7, 10–12, and 13–15.

4.—Portion of another individual representing whorls 12–16 (?).

5.—Portion of three whorls (13–15 ?) of a third individual.

6.—Apical view of the nucleus of the *dextral* specimen (= Fig. 1 of *B*).

B.—Dextral form :—

FIG.

7–6.—Associated parts of the individual shown in Pl. X, and representing whorls 1–2, 4, 7–9, 11–14, 15–21, and 22–23 respectively.

7, 8.—Portions of other individuals with flatter whorls, showing the twofold fracturing resulting in the formation of wedge-shaped pieces.

9.—Portion of another example with more tumid whorls.

10.—Apical view of the nucleus of the sinistral specimen (= Fig. 1 of *A*).

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The Geology of the Far East Rand and the Heidelberg District, Southern Transvaal.—A Retrospect.

By F. H. Hatch.

HEIDELBERG, a town of insignificant proportions, lies 30 miles due south-east of Johannesburg at the foot of the Zuikerboschrand, a range of hills running south-west towards the Vaal River and made up of the volcanic beds of the Ventersdorp System and of the Elsburg series at the top of the Witwatersrand System. Travelling south-east from the Zuikerboschrand, the whole of the Witwatersrand formation is traversed in descending order. The district, which extends south-west of Heidelberg to Goedverwachting, a distance of 20 miles, and south-east to Greylingstad, another 30 miles, has a complicated geological structure, the succession being disturbed by faulting, broken by numerous igneous intrusions and obscured by frequent outliers of the Karroo formation. It is well known to the mining community on account of the fact that a gold-bearing conglomerate bed has been worked profitably at the Nigel Mine since the earliest days of the gold-fields, while numerous other reef outcrops in different parts of the district have induced much active prospecting, which has continued to the present day.

On coming to the Rand in 1892, one of the first tasks allotted to me by my employers (the South African Trust & Finance Company, then under the able direction of the late W. Y. Campbell) was to attempt to unravel the intricacies of this district and to see what relation its auriferous conglomerates bore to those of the Rand. In those days the Main Reef had only been traced, as such, from Johannesburg eastward to Boksburg, where it disappears under an outlier of the Karroo formation. The workings of the Kleinfontein, Van Ryn, Modderfontein, and Nigel companies were considered to be on independent series of conglomerate beds.

Starting at Johannesburg and going eastward, I mapped the country immediately north of the mines, and was thus able to prove the geological identity of the Kleinfontein conglomerates with those of the Main Reef series. I then showed that the reefs worked by the Kleinfontein, the Van Ryn, and the Modderfontein companies, although apparently independent, were in reality faulted portions of the same bed, although a higher horizon lying between the Main and the Bird Reefs was also worked in places by the Van Ryn, Chimes, and Modderfontein mines. (See Fig. 1.)

In 1893 I reported to my employers as follows :—

> "My recent visit to Heidelberg has made it appear probable to me that the 'reefs' worked at the Nigel and at the Heidelberg-Roodepoort, as well as those exposed at Malans Kraal, Tweefontein and Rietfontein, and on Botha's Kraal and Poortje are portions of the same series."

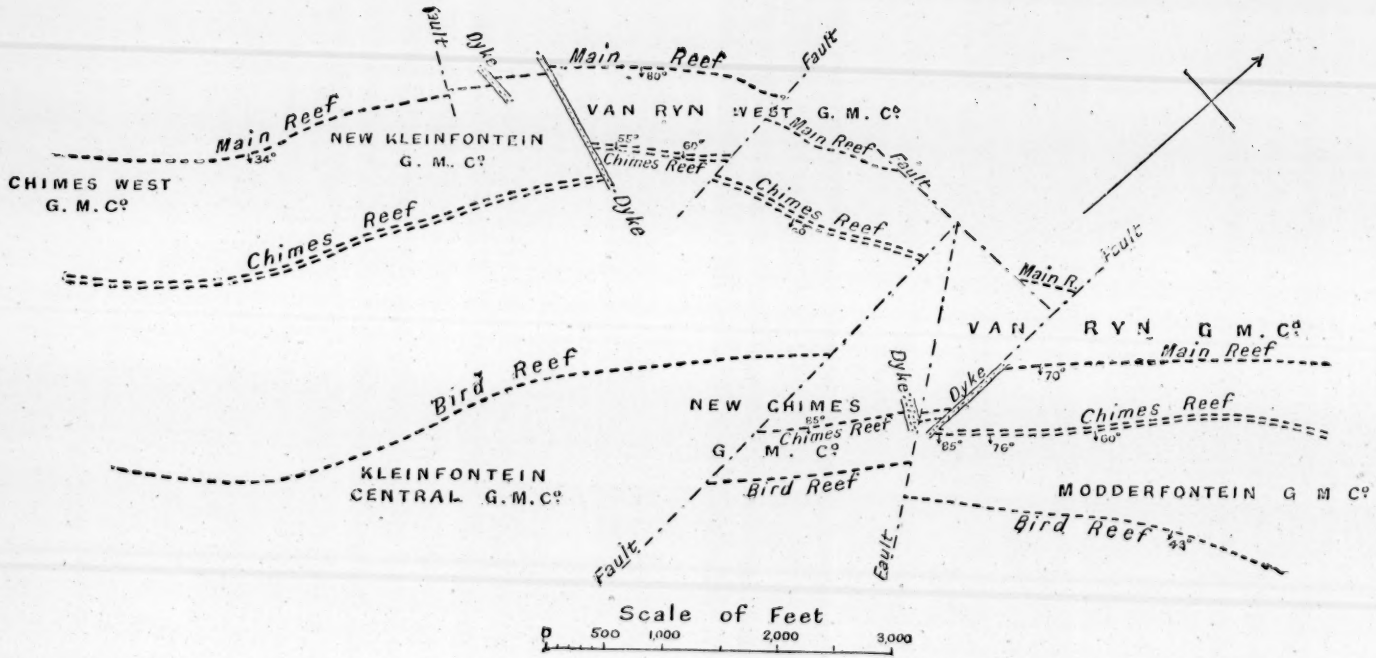

FIG. 1.—Plan of Reef Outcrops in the Kleinfontein, Van Ryn, Modderfontein Area. (Reproduced from the *Quart. Journ. Geol. Soc.*, 1898, p. 80, by permission of the Council.)

I added :—

"It must be remembered that what are termed 'reefs' are simply the marginal outcrops of large sheets of conglomerate covering many square miles and extending down to the Vaal River and into the Free State. In tracing the extension of the 'reefs', therefore, we are simply determining the boundaries of these sheets. The problem is evidently one which admits of solution and should present no great difficulties to a trained geologist who has the time to devote to it. The main points that should guide the intending investigator are :—

(1) The slate footwall of the Main Reef series.
(2) The presence of a series of big Reefs higher up in the order of stratification (Bird series).
(3) The presence of another group of Reefs still higher up in the succession (Kimberley series).
(4) A large series of coarse conglomerates at the top (Elsburg series).
(5) The presence of an alternating series of quartzites and slates below the Main Reef series (Hospital Hill formation).

I have already communicated the results of my investigations on Vlakfontein (i.e. the Van Ryn property) and Modderfontein, showing that the conditions enumerated above are in most parts fulfilled in this district, namely : the Main Reef with its slate footwall, the slates and quartzites (Hospital Hill formation), underlying the banket formation, and the presence of the Bird Series above. Through Modderfontein I have traced the outcrop of the reefs to Klipfontein. I now find that the Nigel fulfils the same conditions : the reef rests on slate, and, at the proper distance above, are found the Bird and the Kimberley series."

In 1897 I published these results in the first edition of my *Geological Map of the Southern Transvaal*, which was reproduced in a paper read before the Geological Society of London in February, 1898,[1] In this paper I said :

"East of Johannesburg the Hospital Hill series can be traced to Klipfontein, about 12 miles north-east of Boksburg, where it disappears under the Dolomite. It is next found at Boschmanskop and Vlakfontein, some 10 miles north-west of the Nigel, and is there striking nearly due south and dipping west. It is apparent, therefore, that, while hidden by the Dolomite and the Karroo formations, the strata have swerved round to the south—an important point in connexion with following up the auriferous conglomerates of the Main Reef series. The outcrops of this formation on Uitkyk, Frischgewaagd and Kuilfontein closely

[1] Hatch, "A Geological Survey of the Witwatersrand and other districts in the Southern Transvaal" : *Quart. Journ. Geol. Soc.*, vol. liv, 1898, p. 73.

resemble those of Hospital Hill, and, like the latter, are faulted up against granitic rocks."

When at the close of the Boer War in 1902 I returned to Johannesburg, I had, as consulting engineer to Messrs. Lewis & Marks, a good opportunity of renewing my researches in this district. Messrs. Lewis & Marks held the controlling interest in Grootvlei No. 45 and Palmietkuil No. 61, and, being anxious to prove the value of these farms, were willing to spend a large sum of money in boring. Lying mid-way between the points where the Witwatersrand beds disappear under the Dolomite at Klipfontein and where they re-emerge with dip reversed from below that formation on Marievale in the Heidelberg district, the ground could not, on my theory, be far from the centre of the syncline formed by these beds and was, therefore, admirably situated for testing its validity.

Having been given a free hand, I set to work by laying out an east-and-west line of boreholes, which, together with one previously put down on Geduld, extended over 10 miles of country. By means of these borings I felt certain I should be able to locate below the Dolomite the sub-outcrop of what I termed the "Van Ryn-Nigel" reef.

The first two boreholes were too far to the east, and, after passing through 700 feet of Dolomite capped by Karroo beds, entered the Lower Witwatersrand. The third borehole was abandoned by the contractors while still in the Dolomite. The fourth entered a dyke at the critical moment and was given up. All these holes were on Palmietkuil.

I then went to the western boundary of the farm Grootvlei, and was successful there in striking the Van Ryn-Nigel, or Main, Reef at a depth of 3,414 feet. The next borehole was on the boundary between the two farms Grootvlei and Palmietkuil and struck the reef at 2,376 feet. Two more holes were put down: one on Grootvlei, which struck the reef at 4,299 feet, and one jointly with the Daggafontein Company, immediately south of the Grootvlei boundary, which intersected the reef at 5,540 feet. This last-named hole was found by survey to have been deflected considerably from the vertical—in fact, the horizontal distance between the mouth of the borehole and the point where the reef was intersected in it was 2,225 feet. After making the correction necessitated by this deflection, the vertical depth of the intersection of the reef was found to be 4,880 feet.[1]

Five boreholes, therefore, gave sections of the Upper Witwatersrand beds, which in all of them are characterized by certain unmistakeable features. These are:—

[1] The particulars of this borehole were published in my report to the Directors of the East Rand Mining Estates, Ltd., and issued in the Annual Report to the shareholders for the year ending 30th June, 1905. The particulars of the other boreholes and a general summing-up of the results are given in my paper on "The extension of the Witwatersrand Beds eastward under the Dolomite of the Southern Transvaal": *Trans. of the Geol. Soc. of S.A.*, vol. vii, 1904, p. 57.

(1) Numerous conglomerate beds belonging to the Kimberley series. Over 100 were cut in Grootvlei borehole No. 2, and there were even more in the Grootvlei-Daggafontein joint borehole.

(2) A band of slates, varying from 200 to 400 feet in thickness, at the base of the Kimberley series.

(3) A bed of amygdaloidal basic lava, from 130 to 360 feet thick, immediately above the Bird conglomerate. I called this "the amygdaloidal diabase"; it has since been called the "Bird amygdaloid", and this is a better name.

(4) A bed of slate immediately under the Van Ryn-Nigel, or Main, Reef.

The most complete section of these Upper Witwatersrand beds was afforded by the Grootvlei-Daggafontein joint borehole. It is as follows:—

	Thickness.[1] *Feet.*	*Depth of base below surface.*[1] *Feet.*
Karroo Beds	111	111
Dolomite with Black Reef at base	1,029	1,140
Kimberley-Elsburg Series.—Quartzites and numerous conglomerate beds . .	2,000	3,140
Kimberley Slates . . .	408	3,548
Quartzites	189	3,737
Bird Amygdaloid . . .	365	4,102
Main-Bird Series.—Quartzites with few strings of conglomerate	778	4,880

Both the Kimberley Slates and the Bird Amygdaloid formed most useful "markers" for calculating the depth at which the Main Reef would be cut. A preliminary estimate could always be made as soon as the base of the Kimberley Slates had been reached, and a still closer estimate was possible as soon as the Bird Amygdaloid had been intersected.

By means of the data furnished by these borings, together with the results of previous borings on the farms Geduld, Daggafontein 94, Rietfontein 182, Vlakfontein 21, and Grootfontein 152, I was able to trace the course under the Dolomite of the sub-outcrop of the Van Ryn or Main Reef as far as the Nigel mine, and, by drawing contour lines at intervals of 1,000 feet depth, to indicate on a plan [2] the nature of the syncline in which it occurs. (See the section in Fig. 2.)

The completion of the work of the Geological Survey in the Witwatersrand District and its publication in "Sheet 52, Johannesburg", fully confirms the correlation of the Nigel with the Van Ryn reef; and the recent publication by Dr. Rogers,

[1] Corrected for deflection from the vertical.

[2] See the plan accompanying my paper on "The Extension of the Witwatersrand Beds eastward, etc.", loc. cit.

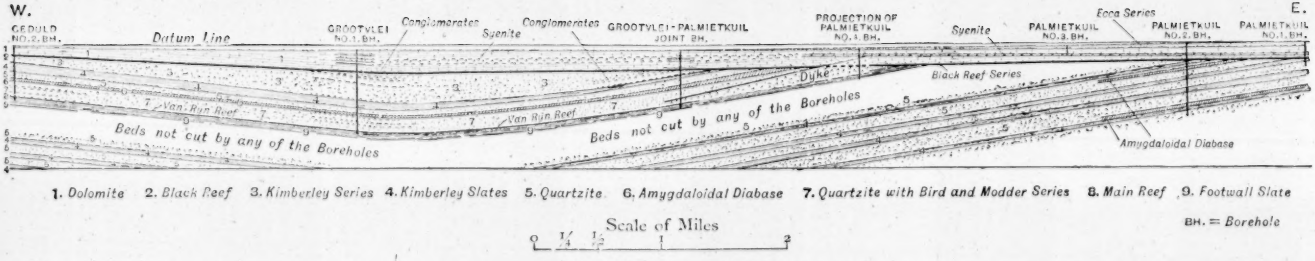

FIG. 2.—Section through the Grootvlei-Palmietkuil boreholes. (Reproduced from *The Geology of South Africa*, p. 136, by the courtesy of Messrs. Macmillan & Co.)

Director of the Survey,[1] of the results of his work in the Heidelberg District, shows the general correctness of the lines drawn by me for the outcrops of the Witwatersrand Beds in that area. But his detailed work, which is reproduced in the beautiful little map accompanying the paper, marks a great advance in the knowledge of the tectonic structure of the district and throws a flood of light on complexities that had completely baffled previous observers.

His most illuminating discovery is the existence, in the southern part of the district, of a great east-and-west fault. This disturbance, named by Dr. Rogers the "Sugarbush Fault", has been traced for 30 miles, from Rietbult 322 in the east, where it emerges from beneath the Karroo rocks, westward to Goedverwachting 306, where it is again covered by Karroo beds. It has a throw which increases from 4,000 feet in the west, where it is first seen in the valley of the Zuikerboschrand River to 14,000 feet on Rietfontein 72 in the east, where it lets down the Ventersdorp lavas to the level of the lowest beds of the Witwatersrand System.

The outcrop of the Ventersdorp beds on the south, or down-throw side of the fault, is from 4 to 5 miles wide, and the volcanic beds are followed in downward succession by Upper and Lower Witwatersrand with the gold-bearing conglomerates of Malanskraal and Tweefontein at their junction. A section drawn in a south-easterly direction through the town of Heidelberg shows a complete duplication of the Witwatersrand succession. Dr. Rogers' map does not extend far enough to the south-east to take in the exposures of Witwatersrand beds at Hexriver and at the Heidelberg-Roodepoort mine, which have been the scene of much prospecting and some mining, but it seems likely that fault lines of a similar nature, and probably parallel to that described by him, will have to be drawn in order to explain the present position of the beds. The extension of his work in this direction will be awaited with considerable interest.

Another important observation of Dr. Rogers is that showing the existence of passage beds between the Kimberley-Elsburg beds at the top of the Witwatersrand System and the volcanic series at the base of the Ventersdorp System, thus demonstrating that there are no grounds for the assumption of an unconformity at this horizon. "The observed facts," he says, "indicate that volcanic activity began whilst the small pebble conglomerate and grit taken as the the top of the Kimberley-Elsburg series of Heidelberg, was being formed and that for some time afterwards quartz grit was furnished to areas where volcanic tuff formed the bulk of the sediment deposited. The arenaceous deposits were outweighed by the volcanic; there is no evidence of a sudden and complete cessation of the supply of sand, but it came in at too slow a rate to maintain

[1] Rogers, "The Geology of the neighbourhood of Heidelberg": *Trans. Geol. Soc. S.A.*, vol. xxiv, 1921, p. 17. It is to be noted that Dr. Rogers will have none of Mr. Bleloch's correlation of the conglomerate overlying the Kimberley Slates with the Van Ryn reef. See p. 47, et seq.

the predominantly sandy character of the deposit. It would be difficult to find better evidence of the conformable succession of volcanic rocks on sedimentary than that offered by the Elsburg-Ventersdorp passage beds in that part of Heidelberg so far surveyed in detail."

In this connexion I would point out that coarse boulder beds forming the upper part of the Ventersdorp System and containing large pieces of auriferous conglomerate and quartzite evidently derived from the destruction of Witwatersrand beds have been recorded as resting on Lower Witwatersrand beds at Ratzekaiskraal and Makokskraal to the north-west of Ventersdorp.[1] Molengraaf also, in describing similar boulder beds at Zendelingsfontein to the west of Klerksdorp and at Kroomdraai to the north of Krugersdorp, refers to their unconformable position on Witwatersrand beds.[2]

This evidence of the existence of a break somewhere in the succession of the Ventersdorp system, taken in conjunction with Dr. Rogers' conclusions as to the conformable relation of the volcanic beds, forming the base of the Ventersdorp system, to the Upper Witwatersrand makes it appear probable that further work may show the necessity of placing the division between the two systems at a different horizon.

The Use of Gryphaea in the Correlation of the Lower Lias.

By A. E. Trueman, D.Sc., F.G.S., University College of Swansea.

In the course of recent investigations in the littoral Lias of South Wales and parts of Somerset the writer has frequently found that almost the only fossils in some of these deposits are species of *Ostræa* and *Gryphæa*, which occur in regular sequence and are of considerable value in correlation. On consulting the literature describing these genera it became apparent that the specific names have been frequently misapplied. From correspondence with other students of Liassic rocks it also appeared that there is some difference of opinion concerning the precise horizons at which such species are to be found.

It was therefore necessary to investigate the various forms of *Ostræa* and *Gryphæa* found in the lowest zones of the Lower Lias, and also to examine sections of the zones where they are normally developed in order to correlate the ammonite sequence with the *Ostræa-Gryphæa* sequence. This paper contains a brief account of the results of these inquiries.

[1] Hatch, "The Boulder Beds of Ventersdorp, Transvaal": *Trans. Geol. Soc. S.A.*, vol. vi, 1903, p. 95.

[2] Molengraaf, "A hitherto unrecognized Formation underlying the Black Reef series": *Trans. Geol. Soc. S.A.*, vol. vi, 1903, p. 68.

The relation of *Gryphæa* to *Ostræa* has been noticed by many workers, and it is generally accepted by palæontologists that species of *Gryphæa* have evolved from *Ostræa* by the shortening of the period of attachment and the arching of the left valve.[1]

Numerous workers have published accounts of these fossils, and some have attempted a systematic study[2]; one of the most interesting papers, published by Jones in 1865, is illustrated by plates showing the relation of species to *Gryphæa incurva*.[3] Nevertheless, much research is needed before the relations of the Liassic *Ostræida* can be properly determined and before the various species can be usefully employed in detailed stratigraphical work. Dr. F. L. Kitchin has been for some years collecting material with a view to publishing an account of *Gryphæa*; his work, however, has been delayed, and he has generously encouraged me to prepare this account of some of the species from the Lower Lias. Such an account is a necessary preliminary to the publication of the results of the work on the Lower Lias of South Wales.

The writer desires to thank numerous friends for help in the field, particularly Mr. E. Drew and Mr. W. F. Howarth, who have made extensive collections at various localities. Dr. W. D. Lang, Mr. L. Richardson, and Mr. J. W. Tutcher have also assisted by the loan of specimens. The writer also acknowledges a grant from the Royal Society Committee which has enabled him to work in Somerset.

The Lowest Zones of the Lower Lias.

The lineage of *Gryphæa incurva* is represented only in the lowest zones of the Lower Lias, which are commonly known as the *planorbe*, *angulata*, and *bucklandi* zones. Recently these zones have been subdivided by Mr. S. S. Buckman[4] and Mr. J. W. Tutcher,[5] and, although some of the divisions are not found in all areas, the present work has shown the necessity of subdividing the original zones, particularly in Glamorgan, where these zones are unusually thick. For convenience, the subdivisions will be called sub-zones in this paper.

Reference will be made to the following:—

[1] See R. T. Jackson, "Phylogeny of the Pelecypoda: The Aviculidæ and their Allies": *Mem. Bost. Soc. Nat. Hist.*, vol. iv, 1890, p. 317. F. L. Kitchin, "Summary of Progress": *Geol. Survey*, 1911. A. Morley Davies, *An Introduction to Palæontology*, 1920, p. 89.

[2] See, for example, M. Hébert, "Observations sur les Gryphées du Lias, etc.": *Bull. Soc. Geol. France*, ser. II, vol. xiii, 1855, p. 213; and O. Terquem, "Paléontologie de l'Etage Inférieur de la Formation Liasique, etc.": *Bull. Soc. d'hist. nat. de la Moselle*, ser. II, vol. v, 1855.

[3] John Jones, "On Gryphæa Incurva and its Varieties": *Proc. Cottes. Nat. Club*, vol. iii, 1865, pp. 81–95.

[4] S. S. Buckman, "Jurassic Chronology: I. Lias": *Quart. Journ. Geol. Soc.*, vol. lxxiii, 1918, p. 274.

[5] J. W. Tutcher, ibid., pp. 278–81.

Zone.	*Sub-zone.*
semicostatum	
bucklandi	*Agassiceras (sauzeanum).* *scipionianum.* *gmuendense.* *vercingetorix.* *bucklandi.* *rotator (rotiforme).* *Vermiceras.*
angulata	*angulata.* *liasicus.* *Wœhneroceras (megastoma).*
planorbe	*Johnstoni (Caloceras).* *planorbe.* *Ostræa.*

It has been found in general that flat oysters of the *Ostræa liassica* pattern are commonest in the lowest part of the *planorbe* zone, and that arched or semi-gryphæate individuals resembling *Ostræa irregularis* are common in the *liasicus* sub-zone. In the *angulata* sub-zone the most typical forms are more gryphæate in appearance, but have generally a fairly large area of attachment and resemble *G. dumortieri* Joly. In the lowest part of the *bucklandi* zone wide open *Gryphæas* (Figs. 1*c* and 2*a*) are found in Somerset and in Glamorgan, while in the upper *Vermiceras* and lower *rotator* sub-zones are very abundant forms resembling *G. obliquata* Sow. The very arched *G. incurva* Sow. is found in the higher sub-zones of the *bucklandi* zone.

Evolution of Gryphæa incurva.

Besides the above-named species of *Ostræa* and *Gryphæa* these lower zones of the Lower Lias are characterized by great numbers of gryphæate and semi-gryphæate forms. These exhibit remarkable variation, but on the whole the individuals may be considered to be members of a series that includes the flat oysters of *O. liassica* pattern and the closely coiled *G. incurva*.

In the opinion of the writer, this represents a true genetic series or lineage, and *G. incurva* has probably evolved through innumerable intermediate stages (including *G. obliquata*, *G. dumortieri*, and *O. irregularis*) from oysters of the type of *O. liassica*. Indeed, it is doubtful whether any better example of a lineage of fossil forms could be found for demonstration purposes, since *Gryphæa* is so abundant that sufficient specimens can be obtained to illustrate the most minute changes.

In such a series various progressive characters may be observed, of which the following appear to be most important:—

1. The arching of the left valve increases until it is coiled through more than one and a half whorls.
2. The area of attachment is progressively reduced.

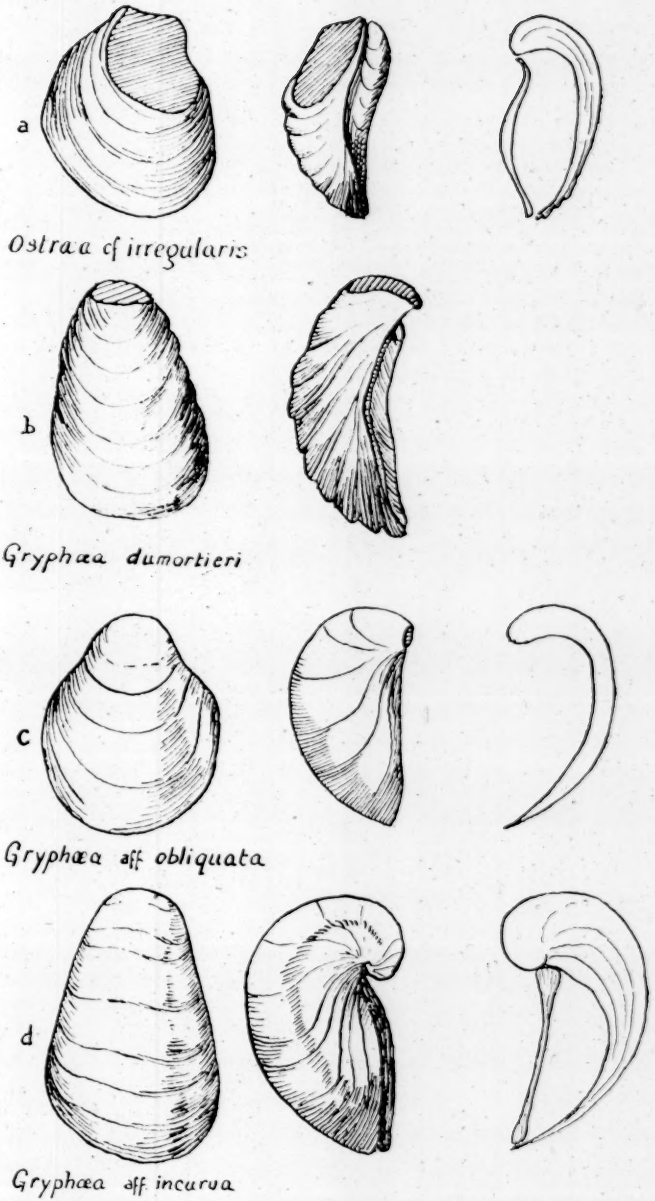

FIG. 1.—Four members of the lineage of *Gryphæa incurva*, showing the left valve, the shell as viewed from the posterior side, and the left valve in section. The area of attachment is shaded. (*a*) *Ostræa* cf. *irregularis* Munst., Lavernock Shales, Lavernock, Glam. (*b*) *Gryphæa* cf. *dumortieri* Joly, *angulata* sub-zone, Dunraven, Glam. (*c*) *G.* aff. *obliquata* Sow., *Vermiceras* sub-zone, Workhouse Quarry, Keynsham, Somerset. (*d*) *G.* aff. *incurva* Sow., ? *gmuendense* sub-zone, near Bridgend, Glam. (slightly reduced).

3. The left (attached) valve is thickened.

4. A sulcus appears on the posterior portion of the left valve; this is developed at a late stage in forms like *G. obliquata*, but at an earlier stage in more advanced forms such as *G. incurva*.

5. The more advanced shells are generally larger.

6. The twist of the left valve seen in *O. irregularis* becomes confined to the apical portion of later species.

The features characteristic of several species are summarized below, and some of the characters named above are illustrated diagrammatically in Fig. 1. The twist of the apical portion of the left valve is shown also in Fig. 2, *a*, *b*; in *G. incurva*, shown in *c* of the same figure, the twist is confined to the apical portion, and is therefore concealed in an adult specimen.

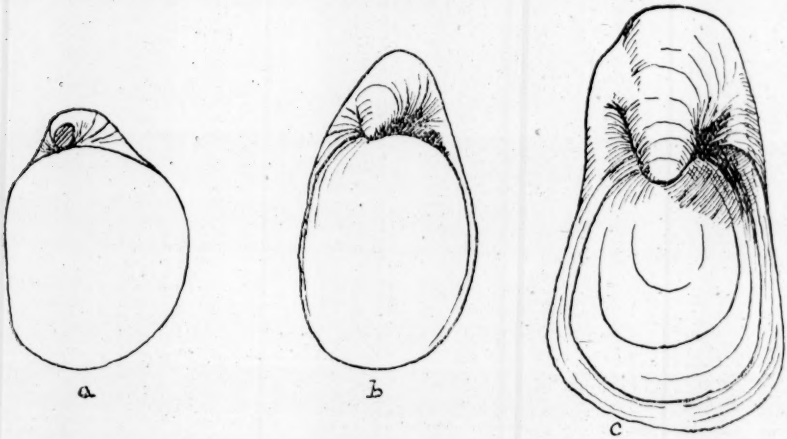

Fig. 2.—Members of the lineage of *Gryphæa incurva*, viewed from the right, to show the twist of the apical portion of the left valve. (*a*) *Gryphæa* aff. *obliquata* Sow., specimen shown in Fig. 1 (*c*). (*b*) *G. obliquata* Sow., a topotype, St. Donats, Glam. (*c*) *G. incurva* Sow., a topotype, Fretherne, Glos.

It is possible that the lineage as here defined includes more than one series, differing only in such characters as the size or breadth of the shell, but there does not appear to be any reason for attempting to separate them now.

The Curve of the Gryphæan Shell.

It has already been noticed that the curve of the left valve of *Gryphæa* approximates to a logarithmic spiral.[1] In such spirals, it will be recalled, the constant angle for the spiral is the angle between a tangent to the spiral at any point and a line passing through that point and the origin (o) of the spiral. Thus in Fig. 3 *a* is the angle of the spiral.

[1] D'Arcy Wentworth Thompson, *On Growth and Form*, 1917, p. 534.

Measurement of the spirals of the Gryphæas studied has shown that the spiral angle α is the lowest in the most primitive members, and increases to about 80° in *G. incurva*.

In general it also appears that in the development of a gryphæate shell the angle α increases in a corresponding manner. In the early stages of *G. incurva* the angle may be only 60°, as it is in the adult stages of *G. obliquata*.

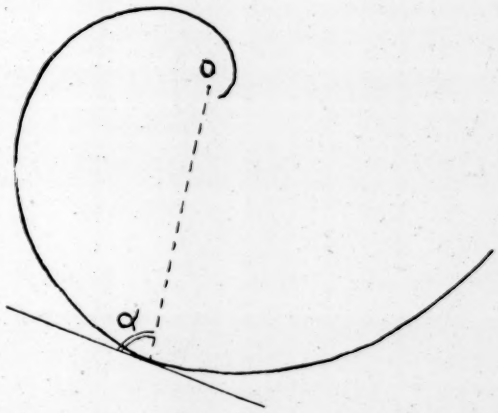

Fig. 3.—Diagram of a gryphæan spiral. Spiral angle, α; origin, o.

The Use of Gryphæa in Correlation.

As we have noted, the lineage of *G. incurva* ranges from the Oyster Beds at the base of the Lias, where it is represented by flat, oyster-like forms, to the *bucklandi* zone, where it is typically represented by very incurved forms. Consequently the various horizons of the Lower Lias can be identified from a study of the Gryphæas, even when no ammonites are present. For instance, the Gryphæas have proved of considerable value in correlating the littoral Lias of Glamorgan, in which ammonites are very uncommon. In those cases where ammonites have subsequently been found, they have invariably confirmed the conclusions that had been based on *Gryphæa*. It is possible to identify both the zones and the sub-zones in this way.

Some caution is necessary in deciding the precise horizon of beds with *Gryphæa* on account of the variation within the group. Even in the same block of stone they often exhibit marked differences. In a large collection from one horizon it will generally be found that about half the specimens are of similar aspect, with left valves coiled to almost the same extent. Of the remainder, some are less coiled and some are more coiled than the average.[1]

[1] Among Liassic Gastropoda, and some families of Ammonites, it is not uncommon to find adult specimens at the same horizon at somewhat different stages of evolution; some are more "highly accelerated" than others. The differences between the Gryphæas, however, are much more apparent.

The number of whorls forms a measure of the coiling, and also, in a general way, is an indication of the position in the lineage. A curve may be constructed like that in Fig. 4 showing graphically the proportions of specimens from a particular horizon with the various degrees of coiling. It will be noticed from Fig. 4 that the majority of specimens of *G.* cf. *incurva* from the *gmuendense* sub-zone of Bridgend are coiled through more than a whole whorl; a few are coiled for considerably more than a whorl, while others are coiled for only three-quarters of a whorl. The difference in aspect between these two extreme forms is considerable, and it is obviously impossible to determine the horizon represented if only a few specimens are available.

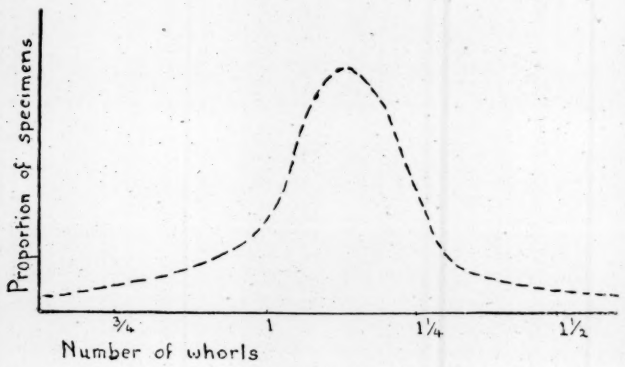

FIG. 4.—Graph based on a collection of *Gryphæa* aff. *incurva* from a horizon in the *gmuendense* sub-zone, Bridgend, Glam., to show the proportions of specimens in various stages of coiling.

When these facts are remembered it is easy to understand the confusion that has arisen concerning the horizons at which various species are found. For example, *G. incurva* has been recorded by various writers from the *planorbe* zone, the *angulata* zone, and the *bucklandi* zone, and although many of the records probably refer to specimens that are really less advanced than the true *G. incurva*, it should be noted that quite curved forms of *Gryphæa* occur somewhat rarely in the *angulata* zone, and not uncommonly in the lower part of the *bucklandi* zone.[1]

In Fig. 5 are shown graphs representing the proportions of specimens in the various coiling stages from several horizons of the Lower Lias. In the lower portion of the *angulata* zone (*liasicus* sub-zone) *Ostræa irregularis* represents the *G. incurva* lineage, and rarely shows a curve of more than a quarter of a whorl. The Gryphæas of the *Vermiceras* sub-zone are typically curved through

[1] The very curved forms from the *angulata* zone generally differ from *G. incurva* in having a feeble sulcus (if any) and a larger area of attachment. They are, therefore, accelerated in some characters only.

more than half a whorl and occasionally more than three-quarters, while the Gryphæas of higher zones may rarely be less curved than three-quarters of a whorl, but are generally a whole whorl or more. In other words, some specimens, perhaps five per cent, in the lower *Vermiceras* sub-zone are as advanced as those in the *gmuendense* sub-zone, but the majority of specimens at each horizon illustrate the trend in the evolution of the group.

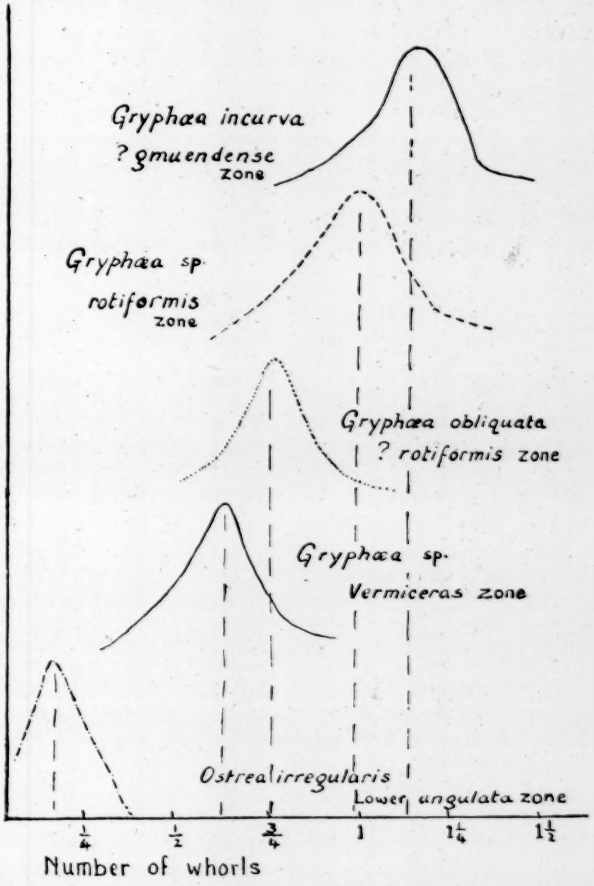

FIG. 5.—Graphs based on collections of gryphæate specimens from several horizons to show the proportions of specimens at each horizon in the various stages of coiling.

[*For* "zone" *read* "sub-zone."]

When using *Gryphæa* in the field for determining the zone it is advisable whenever possible to record the coiling of not less than

fifty, and preferably more than a hundred, adult specimens, from a particular horizon. It will generally be sufficient to note the coiling and any other prominent characters, and it is not usually necessary to preserve large numbers of specimens. There is frequently some difficulty in judging exactly the number of whorls present in uncleaned specimens, particularly in the more advanced members of the series. If all the records are made by the same observer, however, any small inaccuracies do not appear to be of very great practical importance. From these data a graph may be constructed and the zone may be determined by comparison with graphs made from known horizons.

Relation of G. incurva to other Gryphæate Series.

It is not necessary in this paper to describe other gryphæate forms, but it may perhaps be usefully noted that other Gryphæas, such as *G. cymbium* and *G. maccullochi*, have probably been evolved from oysters. Indeed, it is extremely likely that these gryphæiform shells have been evolved repeatedly during the Jurassic and

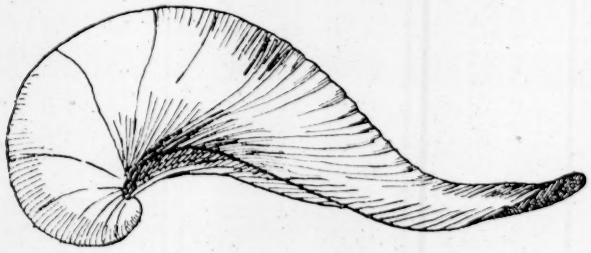

Fig. 6.—A large specimen of *Gryphæa* cf. *incurva* from the *Agassiceras* sub-zone, Kilmersdon Colliery Quarry, Radstock.

Cretaceous from species of *Ostrea* that are similar and are presumably closely related. In other words, "*Gryphæa*" is a polyphyletic group, containing species evolved along many different lines.[1] Therefore, the name *Gryphæa* can only be applied strictly to *one* of these series, and each such series should receive a separate generic name; but until more of their characteristics are known, at least, it appears undesirable to add to the existing confusion by creating new names for each group. Indeed, as homœomorphs in some of the series are almost or quite identical, it would probably be impossible to distinguish many of the genera even though names were available.

Some of these gryphæate series may be distinguished by the measurement of the angle of the spiral (see Fig. 3) and by the form of the beak.

[1] The parallel evolution of these numerous series, each passing almost inevitably through comparable stages, and following what may be regarded as a pre-determined "programme", affords an example of what Dr. F. L. Kitchin has called "programme-evolution". (See W. D. Lang, *Catalogue Cret. Bryozoa*, vol. iii, 1921, p. xviii.)

Many of these offshoots from the oyster family continued to progress in the characters named, particularly in the curving of the left valve, until a stage was reached when the coiled apical portion pressed against the opercular right valve.[1] Thus in such advanced Gryphæas the shell would be kept closed, and consequently this stage marks the limit of evolution in that direction. Occasionally large adult specimens show a tendency to avoid this calamity by reducing the coiling in the later stages (Fig. 6).

It is only necessary here to refer briefly to the interesting biological aspects of the evolution of gryphæan lineages. Although it may be conceded that the earliest stages in such a lineage may have been of some advantage to the animal, it is obviously difficult to account for evolution in a direction that inevitably leads to the extinction of the lineage, if evolution is the result of the operation of natural selection. Dr. W. D. Lang has taken a different view of the relative importance of natural selection, and has suggested that these lineages became extinct through the secretion of a superfluity of calcium carbonate.[2]

Notes on Species.

Ostræa liassica Strickland.

This name conveniently covers the typical oysters of the base of the Lias. A flat form, usually attached by the whole surface, or nearly the whole surface, of the left valve. Commonly about 1 inch to 1½ inches in length.

These shells are most abundant in the *Ostræa* Beds at the base of the Lias, and are also found in the overlying *planorbe* and *Caloceras* sub-zones. In the latter, the oysters are not infrequently moulded on the shells of ammonites. Oysters somewhat similar to this species, frequently of larger size and less regular form, are also found in several higher zones of the Lower Lias.

Some small specimens of *O. liassica*, collected at Lavernock, near Cardiff, and at Owthorpe and Barnstone, near Nottingham, show the initial shell or prodissoconch (Fig. 7). In these young shells the umbo is prominent in the free valve and is directed posteriorly, as in *Ostræa edulis*.[3]

Ostræa irregularis Münst.

O. irregularis Quenstedt. Der Jura, 1858, t. iii, 15*a*, *b*.

Cf. *O. sublamellosa* Dunker, Dumortier. Dépôts jurassiques du Bassin du Rhône, pt. ii, pl. i, 10, 11, 12.

This name is applied to oysters of the Lower Lias that are in a semi-gryphæate condition. The size of the area of attachment varies, but is typically about half the total length of the shell. The left (attached) valve is thickened (Fig. 1*a*).

O. irregularis is characteristic of the *liasicus* sub-zone, and is

[1] As in the type of *G. incurva*.

[2] W. D. Lang, *Catalogue of Cretaceous Bryozoa*, vol. iii, 1921, p. x.

[3] R. T. Jackson, loc. cit., p. 312.

extremely common in the Lavernock Shales in the Cardiff district [1] and in the lower *angulata* zone near Keynsham, Somerset.[2]

Gryphæa cf. *dumortieri* Joly. (Fig. 1*b*.)

G. dumortieri Joly. Les Fossiles du Jurassique de la Belgique, 1908, pl. i, figs. 4–7.

G. sp. Dumortier. Dép. jur. Bass. Rhone, pt. ii, p. 83, pl. xv, 1, 2.

This species is distinguished from *O. irregularis* by its smaller area of attachment, which is not usually more than one-sixth the length of the shell. The curve of the left valve amounts to about one-half of a whorl. This species was described by Joly from the Hettangian of Belgium; specimens which appear to be identical are found not uncommonly in the *angulata* sub-zone of Glamorgan and around Radstock, Somerset.

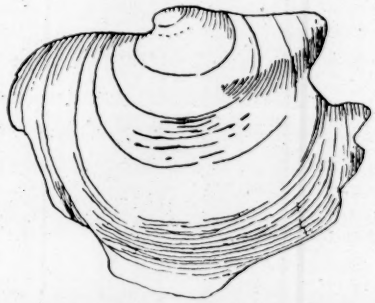

FIG. 7.—Prodissoconch of *Ostræa liassica* Strick. × 8 approx. From the *Ostræa* Beds, Owthorpe, Notts.

Gryphæa obliquata Sow.

Cf. *G. arcuata* var. *rugosa* Munst. Goldfuss, Petref. Germ., pl. lxxxiv, fig. 2*c* only.

This specific name has been applied to many gryphæate forms from various horizons in the Lias. It is necessary therefore to emphasize the characters by which it is distinguished.

Sowerby pointed out that in his species—

1. The attached valve does not form a complete whorl.
2. The beak is twisted to the posterior side (Fig. 2*b*).
3. The area of attachment is small.
4. The shell is broader in proportion than in *G. incurva*.

It may be added that the holotype of Sowerby's species (in the British Museum of Natural History) shows a faint sulcus appearing on the later part of the shell. The shell is not free from matrix, but the apex of the shell appears to be broad and not detached

[1] A. E. Trueman, "The Liassic Rocks of the Cardiff District": *Proc. Geol. Assoc.*, vol. xxxi, 1920, p. 102.

[2] A. Vaughan & J. W. Tutcher, "The Lias of the Neighbourhood of Keynsham": *Proc. Brist. Nat. Soc.*, N.S., vol. x, 1903.

or beak-like. The shell is broken, but at the length of 42 mm. has a breadth of 32 mm.

The holotype is beekitised and was collected in the Blue Lias near St. Donats Castle. Beekitised Gryphæas, agreeing with Sowerby's specimen in size and character, are exceedingly abundant in the limestone reefs forming the shore just west of St. Donats Bay, Glamorgan.

It is likely that these are topotypes of Sowerby's species; ammonites are not commonly found in those beds, but the horizon is the lower part of the *bucklandi* zone (the *Vermiceras* or *rotator* sub-zone). Comparable forms are found on the Dorset coast at approximately the same horizon (W. D. Lang Coll. 4143–6).

Gryphæa incurva Sow.

Cf. *G. arcuata* Lamarck.

The chief characters of this species are the following :—

1. The arched valve makes much more than one complete turn; it frequently represents one and a half whorls.

2. The area of attachment is very small and is concealed in adult shells by the curving of the valve.

3. The shell increases very slowly in breadth, and the breadth is little more than a half the total length (measured across the whorl). In the holotype, the breadth of the arched valve at its widest point is 41 mm.; the diameter or greatest length is 73 mm.

4. The beak does not appear to be oblique at the apex in a complete specimen.

5. A prominent sulcus is present on the shell from an early stage in development.

It must be pointed out again that this name has been frequently misapplied, and emphasis must be laid on the extreme curvature of the left valve of this species.

The holotype (British Museum of Natural History, No. 43343) is a specimen from Fretherne, Glos. The horizon is the *bucklandi* zone (probably the *Agassiceras* sub-zone). Identical forms are known from Purton Passage, Glos. (J. W. Tutcher Coll.); from Bengeworth, near Evesham, Glos. (L. Richardson Coll., L.L. 16 and L.L. 11); and from the railway cutting near Bridgend, and other parts of Glamorgan.

It is, perhaps, desirable to explain why Sowerby's specific name is used here in place of *G. arcuata* Lam., which is supposed to be synonymous. Notwithstanding the similarity between the two, there is no proof of identity. Even if the two species can scarcely be distinguished it does not necessarily follow that they are members of the same lineage, and it is therefore preferable to use Sowerby's name for the specimens from the English Lias.

Note on the Cliff Section at Fretherne, Glos.

The low river cliffs at Hock Crib, Fretherne, about 8 miles south of Gloucester, were examined primarily in order to determine the

precise horizon of *G. incurva* Sow., of which this is the type locality. An account of this section was published by Mr. L. Richardson in 1908.[1] It is unnecessary to repeat the details given by him.

That writer discovered several ammonites and concluded that the zones from *megastoma* to *semicostatus* were present. Ammonites are not now abundant at Fretherne, but it appears from recent observations that no beds lower than the *bucklandi* zone are present. Large *Arietid* ammonites are found in the lowest reef on the foreshore (No. 24 on Mr. Richardson's section). In the same bed the Gryphæas are only slightly arched, with feeble sulcus and with fairly large area of attachment. Gryphæas in the succeeding beds (Nos. 20 and 18) show a more incurved left valve and are generally small. Specimens that are scarcely distinguishable from *G. incurva* are found occasionally in beds 15 and 13, but in the same bands are less coiled specimens. Large specimens resembling the holotype are most abundant in bed 11.

The precise horizon of this cannot easily be determined, but in bed 9, some 5 feet higher, *Arnioceras bodleyi* is present, and presumably the typical *G. incurva* occurs near the top of the *bucklandi* zone at Fretherne. Fragments resembling *Coroniceras gmuendense* were found just below bed 11, and it is certain that the type of *G. incurva* is from the upper part of the *gmuendense* sub-zone or a little higher.

Notes on the Fauna of the Lower Devonian Beds of Torquay.

By F. R. Cowper Reed, Sc.D., F.G.S.

(PLATE XII.)

Part III: Mollusca.

Pterinea (*Cornellites*) *costata* Goldfuss.

In spite of Frech's detailed work on the Devonian *Aviculidæ*, the application of the specific name *costata* to certain members of the genus *Pterinea* is even now a matter of some dispute, and Drevermann [2] considers that Frech [3] included under this name some shells which properly belong to *Pt. Pailletei* De Vern. Walther [4] and Fuchs [5] have more recently described the internal characters. Williams [6] has chosen the species as the type of his new subgenus *Cornellites*.

The one fairly good example from the Torquay district with which

[1] L. Richardson, "The Section of Lower Lias at Hock Crib, Fretherne, Glos.": *Proc. Cottes. Nat. F.C.*, vol. xvi, 2, 1908, pp. 135-42.

[2] Drevermann, *Palæontographica*, Bd. L, 1904, p. 237.

[3] Frech, "Devon. Aviculidae": *Abh. geol. spec. Kart. Preuss.*, Bd. ix, iii, p. 71, t. viii, fig. 2; t. ix, figs. 4–8.

[4] Walther, *Neues Jahrb. f. min. Geol., Beil.*, Bd. xvii, 1903, p. 36.

[5] Fuchs, *Abh. kön. preuss. geol. Landesanst.*, N.F., Heft 79, 1915, p. 31, t. viii, figs. 12–18.

[6] Williams, *Proc. U.S. Nat. Mus.*, vol. xxxiv, 1908, p. 89.

I am acquainted agrees with Frech's figure of a specimen from the Lower Coblenzian of Mormont, Belgium (Frech, op. cit., t. ix, fig. 5), and shows the characteristic broad shallow concave interspaces between the 6–7 sharp narrow radial ribs, all crossed by fine concentric striæ. This left valve has the posterior ear fairly perfect, as well as the whole body, but the anterior ear is not preserved.

Dimensions.—Length (oblique), *c.* 40 mm. Height, *c.* 30 mm.

Horizon.—Lower Devonian (Staddon Grits).

Locality.—Smugglers' Cove, Torquay (S. 63).

Pterinea (*Cornellites*) *spinosa* Phillips.

The internal cast of a left valve from Kilmorie and the external impression of the same specimen in a good state of preservation allow us to determine the presence of Phillips' species *Pt. spinosa*,[1] which is closely allied to, though not identical with, *Pt. costata*. The external impression shows 8 strong radiating ribs subquadrate in section, decreasing successively in size anteriorly, and becoming more curved forwards; they are separated by deep interspaces, two or three times as wide, with a more or less flattened floor. Both ribs and interspaces are crossed by equidistant concentric lamellose lines which rise into projecting imbricating scales on the ribs, and there are also regular radial striæ, 8–10 in number, set at equal distances apart, which ornament each interspace, but they seem absent from the crests of the ribs. The flattened triangular pointed posterior ear bears about 6 or 7 strong raised lines parallel to the hinge-line, with 2–3 finer lines between them, and it is also crossed by closely set fine concentric lines. The somewhat swollen anterior ear bears 2–3 coarse radial ribs precisely similar to those on the anterior part of the body, but separated from them by a particularly wide interspace; the ear and its ribs are also crossed by closely set minutely concentric and radial lines, producing a minute cancellation. In the interior cast of the left valve the small anterior muscle-scar on the anterior ear is situated just below the pair of very stout short anterior cardinal teeth, which lie immediately in front of the beak, but the posterior teeth are not preserved. The posterior muscle-scar cannot be clearly made out.

Dimensions.—Height at beak, *c.* 25 mm. Length of body, *c.* 38 mm. Length of hinge-line, *c.* 60 mm.

The difference between *Pt. spinosa* and *Pt. costata* has been clearly demonstrated by Béclard,[2] and it lies not only in the shape and ornamentation of the ribs, but in the presence of ribs in the anterior ear, similar to those on the body. *Pt. Pailletei* De Vern.[3] is an allied species which Frech united with *Pt. costata* Goldf.

[1] Phillips, *Palæoz. Foss. Devon and Cornw.*, 1841, p. 48, pl. xxii, figs. 81*a–f*.

[2] Béclard, *Bull. Soc. belge Géol.*, i, 1887, pp. 68–73, pl. v, figs. 7–11.

[3] De Verneuil, *Bull. Soc. géol. France*, Ser. II, vol. xii; 1855, p. 1003, pl. xxix, fig. 3; *Oehlert*, ibid., Ser. III, vol. xvi, 1888, p. 639, pl. xiv, figs. 6, 6*a–c*; Drevermann, *Palæontographica*, I, 1904, p. 237, pl. xxviii, figs. 8–11; Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft. 76, 1913, p. 54, t. iii, fig. 6.

Horizon.—Meadfoot Beds.
Locality.—Kilmorie, Meadfoot (S. 62).

Leiopteria (*Actinopteria* ?) *anisota* (Phillips).

The description of this shell given by Phillips[1] is as follows: "Lower [= left] valve.—Convex, with a prominent beak, transversely extended to a width [= length] greater than the length [= height], with very dissimilar wings; the anterior small, round, deeply separated from the body of the shell; the posterior larger, concavely arched and pointed and gradually united to the body of the shell-surface radiatingly striated and concentrically marked by lines of growth. The striæ are conspicuous chiefly near the beak, the lines of growth most prominent on the posterior wing. *Locality*: Meadfoot, in sandy ochraceous shale."

There is a specimen ($\frac{30}{11}$) in the Jermyn Street Museum from this locality which closely resembles Phillips' figure of the type, but the beak is more broken and the radial striæ on the surface are not visible, though the concentric growth-lines are well preserved in the posterior wing. It is probable that it is the original specimen. We may add to the foregoing description the remarks that the body is convex, rather swollen and oblique, and that the posterior ear is depressed and rather concave, though not sharply marked off, and that judging from the course of the concentric lines it was not produced into an acute point, and did not project much or at all behind the body. No teeth are visible. The species seems to belong to the group of *Avicula lamellosa* Goldf. in Frech's[2] classification of the Aviculidæ, and this group includes members of Hall's genera *Actinopteria* and *Leptodesma*. The species *Avicula bodana* A. Roemer[3] is apparently closely allied to our English form, and *Leiopteria Drevermanni* Spriesterbach[4] from the Siegen Graywacke (which its author remarks might be placed in Hall's genus *Actinopteria*) is probably a near relation.

Horizon.—Meadfoot Beds.
Locality.—Meadfoot (M.P.G. $\frac{30}{11}$).

Actinodesma obsoletum (Goldfuss) var.

There is a good internal cast of this shell from Kilmorie in the Sedgwick Museum (S. 65), consisting of a perfect left valve with the greater part of the right valve attached and in position, and the external impression of the umbonal region, ligamental area, hinge-line and anterior margin of the latter valve. The left valve shows the characters described by Goldfuss[5] and other authors, except that there are 12–14 low concentric ridges on the body which is a larger number than that mentioned for the species. The right valve,

[1] Phillips, *Palæoz. Foss. Dev. Cornw.*, 1841, p. 49, pl. xxii, fig. 83.
[2] Frech, *Abh. geol. spec. Kart. Preuss.*, Bd. ix, Heft iii, 1891, p. 49.
[3] Frech, ibid., pl 54, t. iv, figs. 10–10*b*.
[4] Spriesterbach, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxx, 1915, p. 33, t. ix, figs. 5, 6 (? t. x, fig. 1).
[5] See n. 1, p. 271.

on the other hand, appears to have a smooth surface, and the beak is smaller and less prominent than that of the other valve. The longitudinally striated external ligamental area is well seen, and the hinge-line shows a row of small transverse denticulations on its edge between the beaks which is characteristic of *Actinodesma*. The base of the anterior ear of the left valve shows traces of the anterior muscle-scar. An impression of part of the exterior of another left valve (S. 66) shows on the body very strong high upstanding thick concentric lamellæ, which are closely placed and slightly crenulated by weak discontinuous small radial folds. The large flattened posterior ear of this specimen has the characteristic shape and ornamentation of the species, but the concentric lamellæ on the body are more numerous and more closely placed than in typical examples, so that this Torquay form seems to be a variety of Goldfuss' type.[1]

There is another (S. 67) nearly complete, though distorted, internal cast of an entire shell from Kilmorie in the Sedgwick Museum, which also probably belongs to the same species. The right valve is perfect, but the concentric rugae on the surface of the left valve are less apparent than in the above described specimen. There is a well-marked pallial line situated at about one-fourth the height of the shell and the whole pallial area is pitted; the posterior muscle-scar is large and well marked and in the usual position. Drevermann[2] has figured a shell under the name *Actinodesma erectum* Hall, var. *eifeliensis*, from the Lower Coblenzian of Oberstadtfeld, which has the same peculiarly marked pallial line, but our shell has a more subquadrate form and subcentral beak, and in these respects is like *A. obsoletum*. The large concave ligamental area is well preserved in our specimen, and the short rounded prominent anterior ear is complete in both valves, but the posterior wing is broken off and the cardinal denticulations are barely discernible.

Dimensions.—Height of shell: (S. 65) 55 mm.; (S. 67) *c.* 35 mm. Length of body (maximum): (S. 65) 50 mm. Length of hinge-line: (S. 65) 70 mm.; (S. 67) 37 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 65, 66, 67).

Actinodesma (*Glyptodesma*) *suberectum* sp. nov. Plate XII. Figs. 1*a*–*b*.

Definition.—Shell large, high; body narrow, nearly erect, subtriangular, with its sides making an acute angle (about 30 degrees) at the beak; height about one-third greater than length; inferior margin strongly rounded; anterior margin nearly straight above,

[1] Goldfuss, *Petref. Germ. II*, p. 117, t. cxvi, fig. 1*a* (non 1*b*); Follmann, *Verh. Nat. Hist. Verein. Rheinl.*, Jahrg. xlii, 1885, p. 197, t. v, fig. 3; Frech, "Devon. Aviculidæ": *Abh. geol. spec. kart. Preuss.*, ix, iii, p. 107, t. viii, figs. 5–7*a*; Drevermann, *Palæontographica*, l, p. 240; Kegel, *Abh. kon. preuss. geol. Landesanst.*, N.F., lxxvi, 1913, p. 55.

[2] Drevermann, *Palæontographica*, Bd. xlix, p. 83, t. *x*, fig. 3.

broadly arched below; posterior margin nearly vertical, slightly concave. Hinge-line straight, equal in length to about two-thirds the height of the shell. Ears well marked off from body. Valves unequal in size and unequally convex; left valve moderately convex, more so than right valve and larger, with higher and more prominent acute beak, having the body sharply marked off from anterior and posterior ears. Anterior ear small, subtriangular, convex, rounded, depressed, extending only a short distance along anterior edge of shell, with strongly concave inferior margin and byssal gape. Posterior ear large, triangular, flattened, depressed, longer than wide, extending fully three-fourths the length of the body; posterior edge nearly vertical, broadly excavated, with tip pointed at about 60 degrees. Surface of body of left valve (in cast) marked with a few broad, low, concentric rugae, most conspicuous towards the inferior margin. Right valve showing large posterior muscle-scar situated on edge of body towards base of posterior ear. Ligamental area present on both valves, external, elongated-triangular, longitudinally grooved with fine lines. Hinge-line with traces of coarse crenulations in front of beaks.

Dimensions (S. 64).—Height of shell, *c.* 65 mm. Length of hinge-line, *c.* 42 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 64).

Remarks.—There is only one specimen of this shell known to me, and it consists of an internal cast, but it appears to possess such distinctive characters as to merit a specific designation. It can scarcely be regarded as a crushed and elongated example of *Actinod. obsoletum*, though the surface ornament (so far as it is preserved) rather suggests it. In shape and general characters it much resembles the figures and descriptions of the species described by Hall [1] as *Glyptodesma erectum* (Conr.) from the Hamilton group of New York, and the briefly described *Actinodesma Annae* Frech [2] from the Coblenzian, which would have been placed in *Glyptodesma* if Frech had admitted its generic or subgeneric separation from *Actinodesma*; but our shell is less oblique than *A. Annae* and has a less pointed posterior ear. The previously mentioned *A. erectum* Hall, var. nov. *eifeliensis* Drevermann [3] from the Lower Coblenzian of Oberstadtfeld seems to be almost identical with our new species, but it is broader and shorter. Kegel [4] is inclined to unite *A. Annae* with *A. obsoletum*, thus adopting Drevermann's opinion. But it seems advisable to keep our shell separate from all these species.

Kochia capuliformis (Koch).

This species, which is a characteristic one in the Lower Devonian of the Continent,[5] is subject to some variation in shape, and the one

[1] Hall, *Palæont. New York*, vol. v, pt. i, 1884, p. 153, pl. xi, figs. 1–10.
[2] Frech, op. cit., p. 106, t. vii, fig. 11; t. viii, figs. 6–6*b*.
[3] Drevermann, *Palæontographica*, xlix, 1902, p. 83, t. x, fig. 3.
[4] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxiv, 1913, p. 55.
[5] Frech, op. cit., p. 74, t. vi, figs. 6–6*f*; Kegel, op. cit., p. 55, t. iii, fig. 7.

well-preserved cast of a left valve from Kilmorie which is in the Sedgwick Museum appears to be identical in every respect with the shell figured by Frech [1] as a young "*Avicula*-like" example from the Taunus quartzite. The ligamental surface and posterior wing, the typical high narrow swollen body, and the high incurved slightly twisted beak are well seen in our specimen, and there are 2–3 low rounded concentric growth-ridges near the margin. The species does not appear to have been previously recorded in the Meadfoot Beds.

Dimensions.—Height (oblique), 22 mm. Ditto, to hinge-line, 19 mm. Length of hinge-line, 10 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 72).

Modiomorpha cf. *mytiloides* (Conrad).

There is an internal cast of a complete shell from Kilmorie in the Sedgwick Museum which may be compared with the American species *Modiomorpha mytiloides* (Conr.)[2] rather than with any European form which has been described, though it resembles *M. elevata* Krantz,[3] *M. præcursor* Frech,[4] and *M. submissa* Barr. (as figured by Barrois [5]) in many respects. The obliquely suboval or rather spatulate shape of the shell widening gradually to the end of the hinge-line, the narrow projecting anterior pre-umbonal portion, the situation of the umbo, the oblique course of the hinge-line, the weak sinuation in the inferior margin, the faintness or practical obsolescence of the umbonal ridge and the position of the anterior muscle-scar are features which agree closely with the above-mentioned American species. The internal cardinal thickening of the valve, the position of the posterior muscle-scar, and the course of the pallial line are of the usual type found in allied members of the genus, as figured by Hall, but the teeth are not preserved in our specimen, and the exterior of the shell is unknown. It has been suggested by Williams and Breger [6] that the lanceolate cardinal escutcheon on the internal cast represents the convex base of an internal ligament in spite of Halls' statement that the ligament is external.

Dimensions.—Length, *c.* 63 mm. Height (maximum), *c.* 34 mm. Height at back, *c.* 20 mm.

Horizon.—Meadfoot Beds.

Locality.—Kilmorie (S. 73).

[1] Frech, op. cit., t. vi, figs. 6*b*, 6*c*.

[2] Hall, *Palæont. New York*, vol. v, pt. ii, 1885, p. 277, pl. xxxvii, fig. 3; pl. xxxviii, figs. 1–16.

[3] Beushausen, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft xvii, 1895, p. 23, t. ii, figs. 9–11.

[4] Drevermann, *Palæontograph.*, xlix, 1902, p. 86, t. x, figs. 11–14.

[5] Barrois, *Faune Calc. d'Erbray*, *Mem. Soc. Geol. Nord*, iii, 1889, p. 176, pl. xii, fig. 2.

[6] Williams & Breger, Prof. Paper 89, *U.S. Geol. Surv.*, 1916, p. 218.

Palæonelo cf. *Maureri* Beushausen, var. *dunensis* Beushausen.

One imperfect specimen of a left valve from the New Cut, Torquay, seems to show the characters of the shell described by Beushausen as *Ctenodonta* (*Palæoneilo*) *Maureri* var. *dunensis*[1] from the Coblenzian of the Rhine. The complete outline of our example is not preserved, but the special ornamentation is well seen. The latter consists of a few widely separated sharp raised concentric growth-ridges or lamellæ, with a few (4-5) very fine concentric striæ in the broad concave interspaces, and their slight obliquity and increasing distance apart towards the posterior end of the valve distinguish its ornamentation from that of *Tellinites lavisulcus* Etheridge (q.v.). Williams and Breger[2] would place in the genus *Tellinites* McCoy[3] the species *Ct. unioniformis* Sandb., which Beushausen associated with the group containing *Ct. maureri*, but their view is not here adopted.

Dimensions.—Length, *c.* 32 mm. Height, *c.* 16 mm.

Horizon.—Red Beds (Staddon Grits).

Locality.—New Cut, Torquay (S. 24).

Nuculites (*Cleidophorus*) *subovatus* sp. nov.

Definition.—Shell suboval, smoothly rounded, gently convex; anterior end broader and more obtuse than posterior end; inferior margin slightly arched; postumbonal cardinal margin nearly straight. Beak subanterior, inconspicuous, low, situated at about one-fourth the length of the shell. Internal clavicular ridge stout, slightly curved forwards, thickening below but becoming less elevated, extending downwards rather less than half the height of the valve. Cardinal teeth 8-9 in number, long, narrow, transverse, divergent, forming a slightly fan-like group at the origin of the clavicular ridge; anterior and posterior denticulations very small and numerous.

Dimensions.—Length, 31 mm. Height (at beak), 19 mm. Length of clavicle, *c.* 8 mm.

Horizon.—Meadfoot Beds.

Locality.—Meadfoot (Mus. Pract. Geol. $\frac{30}{16}$).

Remarks.—The specimen on which the above description is based is the internal cast of a right valve figured by Phillips[4] as *Nucula ovata* (Sowerby) in the belief that it was identical with the imperfectly known Silurian species from the Upper Ludlow of Horeb Chapel, etc., described by Sowerby as *Cucullæa ovata*.[5] Phillips gave the following definition of the species: "Transversely extended to an ovate form, most obtuse towards the anterior end, and having a width greater than the length in the ratio of 3 to 2. Interior lamina

[1] Beushausen, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft xvii, p. 87, t. vii, figs. 19, 25–7.

[2] Williams & Breger, Prof. Paper 89, *U.S. Geol. Surv.*, 1916, p. 165.

[3] McCoy, *Ann. Mag. Nat. Hist.*, ser. II, vol. vii, 1851, p. 51; id., *Syn. Pal. Foss. Woodw. Mus.*, 1852, p. 286, pl. ix, fig. 31.

[4] Phillips, *Palæoz. Foss. Dev. Cornw.*, p. 39, pl. xviii, fig. 65.

[5] Sowerby, in Murchison's *Silur. Syst.*, p. 602, pl. iii, fig. 12.

1

1b

2

1a

2b

2c

2a

E. T. Talbot, del.

LOWER DEVONIAN MOLLUSCA.

To face p. 275.

directly longitudinal (not oblique) on the anterior side of the beak." No mention was made of the teeth, and the identification of this shell with Sowerby's species is extremely doubtful, while its reference to *Cucullæa* or *Nucula* sens. str. is certainly incorrect. The genus *Nuculites* Conrad (= *Cucullella* auctt.)[1] might well receive it, but it seems desirable to use the name *Cleidophorus* Hall in a subgeneric sense, in the manner suggested by Williams and Breger[2] for those species of *Nuculites* of the type of *Nuculites planulata* Conr. in which the surface is smoothly oval without any trace of a definite postumbonal ridge; and to this group our Meadfoot shell undoubtedly belongs. *Cl. perovalis* Williams and Breger[3] from the Chapman Sandstone of Maine bears a considerable resemblance to it in shape and outline, and *N.* (*Cl.*) *ellipticus* (Maurer) of the Coblenzian (as described by Beushausen[4] under the generic name *Cucullella*) is another allied species.

EXPLANATION OF PLATE XII.

FIG.

1. *Actinodesma* (*Glyptodesma*) *suberectum* sp. nov. Left valve of complete internal cast. Nat. size. Meadfoot Beds, Kilmorie (Sedgwick Museum, Cambridge, S. 64).
1*a*. Ditto. Right valve of same specimen. Nat. size.
1*b*. Ditto. Anterior view of conjoint valves of same specimen. Nat. size.
2. *Goniophora kilmoriensis* sp. nov. Right valve of complete internal cast. Nat. size. Meadfoot Beds, Kilmorie (Sedgwick Museum, Cambridge, S. 68).
2*a*. Ditto. Cardinal view of conjoint valves of same specimen. Nat. size.
2*b*. Ditto. Anterior end (broken) of same specimen, showing triangular cross-section. Nat. size.
2*c*. Ditto. Impression of external surface of left valve (imperfect) of same specimen, showing ornamentation. Nat. size.

[1] Kegel, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft lxxvi, 1913, p. 73.
[2] Williams and Breger, Prof. Paper 89, *U.S. Geol. Surv.*, 1916, pp. 159, 160.
[3] Ibid., p. 151, pl. xxv, figs. 2, 10.
[4] Beushausen, *Abh. k. preuss. geol. Landesanst.*, N.F., Heft xvii, p. 104, pl. v, figs. 9–15.

(*To be continued.*)

REVIEWS.

CORRELATIONS OF THE POST-CRETACEOUS FORMATIONS IN THE PACIFIC REGION. By T. WAYLAND VAUGHAN and others. Reprinted from special publication of Bernice P. Bishop Museum, No. 7, 1921. pp. 713–873.

THIS publication, consisting of papers communicated to the Pan-Pacific Scientific Conference in 1921, gives a summary of the present state of knowledge of the stratigraphy and correlation of the Tertiary deposits in and around the Pacific. The papers deal with (1) New Zealand, (2) Australia, (3) Java, (4) Sumatra, Nias, Borneo, Celebes, Timor, and Oceania, (5) the Philippines, (6) Japanese Territory, (7) Alaska, (8) West coast of North America, (9) Central America and the West Indies, (10) Western South America, (11) the Basis of the correlation of Post-Cretaceous Formations of the Pacific Region.

In the more remote and isolated regions, such as Java, Australia, and New Zealand, the difficulties of correlation are very great. In the case of Java Dr. K. Martin says the faunas of the Tertiary deposits are entirely different from those of Europe, and the Tertiary palæontology of India is still too incompletely known to afford any basis for comparison. The percentage of living species in Java is stated to be greater than in deposits of similar age in Europe; this is accounted for by the fact that in Tertiary times important climatic changes occurred in extra-tropical regions; while no such changes took place in the Tropics; accordingly there were fewer factors which would modify the species, so that the transformation of faunas was less rapid than in Europe, and consequently more species have persisted to the present time. Similar remarks are made by W. D. Warren on the Tertiary fossils of the Philippines.

Along the west coast of North America a difficulty in correlation is due to the existence of zoological provinces from south to north. At the present day the marine molluscan faunas of Panama, Southern California, and Alaska have practically nothing in common, and if they had belonged to a Middle Tertiary instead of the Recent epoch it would have been very difficult to have established contemporaneity. In the Tertiary faunas of the west coast there is similar evidence of temperature zones, which are perhaps indicated even as far back as the Eocene, and in the Upper Oligocene a fairly definite zonal arrangement is seen; this becomes even more evident in the Middle Miocene, as is shown by a comparison of the faunas of this horizon in Southern California, Middle California, and Oregon and Washington. The faunas obtained from the marine Pliocene show still more clearly the effects of temperature differentiation from south to north. Another difficulty in the correlation of the Tertiary deposits of the west coast is due to the existence of numerous partially isolated basins of deposition, with local environments and corresponding local changes in the faunas.

The study of the fossil faunas of the Caribbean region is of fundamental importance for the correlation of the Tertiary deposits of both the Atlantic and Pacific basins, because of the inter-oceanic connexion across Central America which existed during a considerable part of the Tertiary period. It has long been noticed that the fossils in the Tertiary deposits of the West Indies and Central America are more nearly allied to species living in the Indo-Pacific region than to those in the Atlantic. In recent years the work of numerous American writers has considerably extended our knowledge of these resemblances, especially in the Calcareous Algæ, Foraminifera, Corals, Echinoids, Mollusca, and Crustacea. It has been shown that many species or genera which are abundant in the Eocene and Oligocene deposits of the Caribbean region are now extinct in the Atlantic, but have representatives in the Pacific. At the present day the Atlantic fauna is in many respects strikingly different from that of the Indo-Pacific region, but the two faunas were not differentiated from one another in Oligocene times and were only slightly differentiated in the Miocene period.

Except in Trinidad no Lower Eocene is known in Central America and the West Indies, and Middle Eocene is known only in Panama, but Upper Eocene deposits are widely distributed and rest on folded and eroded Upper Cretaceous. The Upper Eocene, of which the type formation is the St. Bartholomew Limestone, shows close relationship with the Priabona formation of Northern Italy. Similarly, the coral fauna of the Middle Oligocene deposits bears close resemblance to that of the Rupelian of Northern Italy.

THE WATER SUPPLY OF CAMBRIDGESHIRE, ETC., FROM UNDERGROUND SOURCES. By W. WHITAKER, B.A., F.R.S. Mem. Geol. Survey, (His Majesty's Stationery Office). 157 pp. Price 7*s.* net.

THE publication of this interesting and authentic record of the underground water supplies of Cambridgeshire, Hunts, and Rutland, has been looked forward to by those interested in providing an adequate water supply to meet the conditions accentuated by the abnormal drought of last year.

The area covered by the work embraces that part of England where the least rainfall is recorded in normal years.

The recent drought, particularly in the Fens, where the domestic water supply is most difficult to obtain, has compelled the local authorities to look seriously into the question of permanent water supplies.

In publishing the work at this time the author may be assured of its appreciation by those who desire to be informed of the best means of improving and enlarging their existing supplies.

The first part of the book deals with the general Geological Formations, Water Bearing Beds, Springs, and Contamination;

and in relation to the latter, interesting details are given of the various tests made on the flow of underground water at Fulbourn in connexion with the Cambridge water supply.

The latter part is devoted to a detailed list of well-sections and analyses of the various well waters.

In connexion with the well-sections there is a lot of information which will be extremely useful to geologists as to thickness of strata and depth to the Greensand, etc.

A complete bibliography and index add to the usefulness of an excellent work.

L. E. Wilson.

Osmiridium in Tasmania. By A. M. Reid. Bulletin 32, Geological Survey of Tasmania. pp. vii+126, with 10 plates (maps) and 12 full-page photographs. 1921.

Of late years there has been a considerable demand for the natural alloy osmiridium or iridosmine for the points of gold nibs for fountain pens, and prices until lately ruled very high. Tasmania is to-day the largest producer of this valuable metal. A remarkable feature is the comparative scarcity of associated platinum in the deposits, which nevertheless are derived from ultrabasic, usually serpentinized intrusions, as in the case of the normal platinum occurrences. Hitherto the output has been chiefly obtained from superficial and alluvial deposits, but the metal has been definitely located in its mother rock, which has also been worked commercially to some extent. In their unaltered condition the metalliferous rocks are mainly bronzite-peridotites, while pyroxenites and their derived serpentines are barren. The chief deposits are found in the river-gravels of the Western Division, while the best-known rock-deposits are those of Bald Hill, Mt. Stewart, and Wilson River. Much of this country is very wild and inaccessible, and there are possibilities of much future development of the industry, though at present owing to a slump in prices it is not very profitable.

Nemorhaedus philisi, nov. spec. ein fossiler Goral aus dem Oberpliocän der Auvergne. By S. Schaub (Basel). Eclogæ Geol. Helvetiæ, vol. xvi, No. 5, January, 1922, p. 558.

In this paper the author describes the remains of at least two individuals of a new species of *Nemorhaedus* (the Goral), a genus of antelopes related to *Capricornis* (the Serow) and to *Budorcas* (the Takin), all confined at the present day to the eastern half of Asia. The material, which includes skulls and most of the skeleton, is so good that there seems to be no reason to doubt the accuracy of the determination. The discovery of this Asiatic form in western Europe is particularly interesting because it probably represents the ancestral form of the peculiarly modified antelope *Myotragus* discovered by Miss Bate in Pleistocene cavern-deposits of the

Balearic Isles. This antelope is especially remarkable for possessing a pair of permanently growing rodent-like lower incisors and very broad stout metapodial bones; a detailed account of its osteology was given by the present writer in the *Philosophical Transactions* (Ser. B, vol. 206, 1915, p. 281, pls. 19–22). There numerous resemblances between *Myotragus*, *Nemorhaedus*, and *Budorcas* were pointed out, the likeness of the feet in *Myotragus* and *Budorcas* being especially striking. *Myotragus*, in fact, as suggested in the above-mentioned paper, seems to be a peculiarly modified insular form of the Nemorhaedine antelopes, formerly much more widely distributed than at present.

C. W. A.

James Hall of Albany, Geologist and Palæontologist, 1811–1898. By John M. Clarke. 8vo, 865 pages, and many illustrations. Albany, 1921. Price $3.50.

PROFESSOR CLARKE, Director of the New York State Museum, was obviously the person fitted to write the life of his predecessor and former chief.

The author is not blind to his subject's faults, and the reader is left with a feeling of sadness that a life which might have been tranquil was made turbulent owing to Hall's temperament.

His geological work is admirably treated, as one would expect from one whose labours have been largely along the same lines as those followed by Hall himself. His great achievements—the establishment of the Palæozoic succession in New York State, the magnificent palæontological researches chiefly embodied in the thirteen volumes on the Palæontology of New York, and his acute discernment of the relationship between geosynclines and mountain-building—are adequately treated, and give an excellent idea of Hall's indomitable energy, his industry, and his genius.

We learn much also of his contemporaries, and as his scientific career extended over a period of nearly sixty-three years, the book practically contains a history of the progress of the study of the Palæozoic rocks of the States during the nineteenth century.

The author of the "life" is evidently concerned about questions of nomenclature. The acquisitive Briton has, it seems, established and named so many stratigraphical systems (as he has occupied so many colonies) that little was left for others. This will, no doubt, be set right when a more satisfactory classification is ultimately adopted, based upon fossil-sequence. In the meantime, apart from priority in naming, the work of Hall must be generally recognized as contributing in a high degree to the definite establishment of the Devonian system.

British geologists will be interested in much new matter concerning Lyell's visits to the States. We recommend the book to our readers: it is a worthy record of a great man.

J. E. M.

MEMORIES OF A LONG LIFE. By T. G. BONNEY, Sc.D., LL.D., F.R.S. pp. vii+112. Cambridge: Metcalfe & Co., Ltd., 1921.

DR. BONNEY has composed a delightful book of reminiscences; we wish it could have been longer. It traverses the whole of the Victorian period, for the author's first recorded experience is the booming of the guns of the Black Rock Fort when William IV died. The first chapter deals with incidents of boyhood, and contains a pleasing account of life in a small provincial town in early Victorian times, and of Uppingham School, where the author received "a more liberal education than schools of that day generally provided", and where he began to acquire an early taste for geology by collecting fossils from the Upper Lias Clay and Lower Oolite. Perhaps the most interesting chapters are those relating to Cambridge, and it is instructive to compare the University life at the time when Dr. Bonney was an undergraduate or a junior fellow with that of the present day. Dr. Bonney is not one of those who think things have changed generally for the worse, for he holds the balance very evenly. As a Liberal, though not a Radical, he was usually on the side of the reformers, but while holding that on the whole the old order has changed for a better, he is emphatically of opinion that some of the practices and customs of modern Cambridge are regrettable innovations, and we gather the impression that life at the University, while gaining in many ways, has suffered in dignity and charm. In a chapter on "The Work and Play of a Long Life", the author describes certain of his travels and Alpine experiences, and this is followed by records of some remarkable meteorological phenomena. The last chapter is upon "Men I have known", and contains interesting reminiscences of Isaac Todhunter, Adam Sedgwick, Charles Kingsley, and other famous men. We take leave to correct one small mistake, and that in a footnote. In referring to the tearing down of palings, etc., to supply fuel for bonfires at undergraduates' "rags", Dr. Bonney says: "I have heard that the first of these outrages on law and good manners was perpetrated in 1898, when the late Lord Kitchener received an honorary degree." The writer of this notice has not forgotten the "rag" in the spring of the previous year, when the Senate threw out the proposal to confer titular degrees upon women, on which occasion there was also a deplorable destruction of property.

F. H. A. M.

REPORTS AND PROCEEDINGS.

GEOLOGISTS' ASSOCIATION.

3rd March, 1922.

"The Geological Structure of North Devon." By Dr. J. W. Evans, LL.B., F.R.S., F.G.S.

Description of the geological succession of beds and correlation with other areas. Dip, cleavage, folding, faulting, and other

structures. Historical survey of the district from the Devonian Period to the present time.

7th April, 1922.

"Some British Fossil Pigs and their bearing upon the Pleistocene problem." By Martin A. C. Hinton.

The paper describes fossil pigs from the Red Crag, Forest Bed Series, High Terrace and Middle Terrace drifts of the Thames. Certain of the species recognized are new and some seem to have an important bearing upon the Pleistocene problem in Britain.

LIVERPOOL GEOLOGICAL SOCIETY.

14th February, 1922.—Professor P. G. H. Boswell, O.B.E., D.Sc., F.G.S., President, in the chair.

The following paper was read: "Bacteria from the Geological Aspect." By R. G. Wills, M.A., M.B. (Cantab).

A general description of bacteria was first given, followed by an account of their physiology in its bearing on geology. Reference was made to sulphur bacteria, the formation of hydrated silicates of aluminium by bacterial agency, as well as the precipitation of calcium carbonate. The iron bacteria were then considered in detail, and various deposits due to their agency described, some local examples being cited. They belong to a group of organisms known as the higher bacteria or Trichomycetes, which perhaps stand in an intermediate position between true bacteria and the higher fungi. The remains of iron bacteria have been found in bog iron ores of recent date, but up to the present no structures recognizable as their fossil remains have been found in earlier rocks. Concerning records of fossil bacteria generally, a fair case for their existence has been made out by workers in this field. The late Bernard Renault in 1896 and 1900 described bacteria in Permo-Carboniferous coprolites and coals, in 1915 Charles D. Walcott described a "micrococcus" from the Algonkian Limestone of Montana, and Dr. David Ellis a bacillus and micrococcus from Cretaceous rocks.

ROYAL GEOLOGICAL SOCIETY OF CORNWALL.

Annual Meeting. 28th March, 1922.

The following papers were read:—

Presidential Address. By R. A. Thomas, M.I.M.M.

In which he advocated a thorough investigation of the granite as being most likely to lead to the successful determination of tin and copper-bearing areas.

"The Microscopic Characters of Cassiterite." By J. M. Coon.

In which he gave a detailed account of the optical characters

of cassiterite illustrated by a series of drawings of microscopic sections; he noted that all sections he had examined showed the cassiterite to possess cleavage.

"Ancient Documents relating to Cornish Mining." By F. J. Stephens, F.G.S.

In which he advocated the possibility of profitable lead deposits still existing in Cornwall.

"Note on a Pegmatite from Carn Marth." By E. H. Davison, B.Sc.

Who described a pegmatite which had recently been exposed and which showed crystals of orthoclase showing Baveno twinning, and crusted with secondary mica on which occurred crystals of tourmaline, purple fluor, blue apatite, etc. The field relations of the pegmatite were described and the genesis of the minerals indicated.

"The Geology of Godrevy." By C. Frazier (student of the School of Mines, Camborne).

In which the writer described the geology of the Godrevy area and gave assay results of the manganese and gold value of the manganese layer in the raised beach of Pleistocene age.

A prize of £5 was awarded for this paper from the proceeds of the Bolitho Fund.

"The Geology of Worras Hill, St. Ives." By A. H. E. Turner (student of the School of Mines, Camborne).

The writer described the geology of Worras Hill and some types of altered granite occurring there. He also dealt with the microscopic characters of the igneous rocks and their altered forms.

"Fossils near Bude." By F. M. H. Stephens (age 14).

In which fish and plant fossils were described as well as some concretions of clay ironstone which occur in the Culm Measures near Bude.

Yorkshire Geological Society.

29th March, 1922.

"Some new Observations on the Glacial Geology of Furness." By Geo. Grace, B.Sc., and F. H. Smith, B.Sc.

To a great extent the topography of High Furness is the result of abnormal erosion during and immediately after the Glacial Period. The series of events that produced the basin-like depression in part of which Coniston Lake lies were described in detail, and it was shown that it originally consisted of two distinct valleys at over 300 feet O.D., and that its present condition is due to the erosion of ice coming down Church Beck and Yewdale, assisted by that from several smaller valleys to the north-east.

This origin is confirmed by the profiles of the various becks which run into it, all of which occupy hanging valleys. Many areas in the valleys and much of Low Furness were eroded below sea-level, and the greatest depth seems to be somewhere about 200 feet below O.D.

As in other areas in the Lake District, the usual evidences of glaciation cease about the 2,000 ft. contour, probably on account of frost action during the latter part of the Glacial Period and since the disappearance of the ice. During the period after maximum glaciation, but before the ice was definitely confined to the present valleys, its motion appears to have ignored the present drainage system completely and evidences of cross-channels cut by these high-level glaciers are very common on the mountain-tops.

One episode in the later Glacial Period was the formation of a lake in the Duddon Estuary, which, for some time, discharged its water across South Furness into Morecambe Bay. Low Furness is an area of deposition and is largely covered with Drift. This is of two kinds:—

1. The Irish Sea Drift, divisible into three horizons: (*a*) The Upper Boulder Clay; (*b*) the Middle Sands and Gravels; (*c*) the Lower Boulder Clay. These contain erratics from many places on the west coast of Cumberland and probably still further north. It has been fully described by Mackintosh.

2. The Local Drift, a heterogeneous series of deposits, mostly of limited extent, and probably with no simple relation to one another; certainly not divisible into three series, as has been claimed by previous writers. The line of demarcation between these two drifts runs across Low Furness from Dunnerholme to Newbiggin. North of this line no erratics have been found which can be ascribed to the Irish Sea Drift.

CORRESPONDENCE.

GAULT AND LOWER GREENSAND NEAR LEIGHTON BUZZARD.

Sir,—We have read Mr. G. W. Lamplugh's paper, "On the Junction of Gault and Lower Greensand near Leighton Buzzard (Bedfordshire)," which has recently appeared in the Geological Society's *Quarterly Journal* (vol. lxxviii, part i). Mr. Lamplugh's main interpretation, violating, as it does, the most elementary principles of zonal palæontology and entailing the correlation with one another of four distinct deposits of widely separate ages, appears to us to be so fantastic as to be unworthy of serious consideration. The fallacy of this attempted correlation must be patent to all who are acquainted with the faunal characterization of the zones in question. Rock-specimens and fossils from these beds may be seen at the office of the Geological Survey by any geologists who are interested. The specimens provide clear evidence that Lower Gault and Upper Gault have been confused by Mr. Lamplugh, and no amount of special pleading will lessen the force of their testimony. As regards the limestone-lenticles found at Shenley Hill, amply shown by their fauna to be of Cenomanian age, the matter is equally simple to those who are competent to make a proper use of the evidence.

The publication of work so fundamentally unsound is the affair of the author and of the Geological Society. Of more concern to us is the misleading character of many of Mr. Lamplugh's numerous references to us and to our published views. Misrepresentation is so frequent throughout the paper that we feel bound to protest. A full analysis would occupy many pages of print; but we may mention briefly a few examples by way of illustration. On p. 13 of his paper, referring to a particular mass of "greensand" below the Gault seen by him in 1904, Mr. Lamplugh suggests that we expressed our opinion that this bed is of Upper Greensand age without having seen the rock. He omits to say that our view was based on a set of specimens obtained by himself and deposited in the collection of the Geological Survey. These specimens are always available for examination, and anybody who understands the subject will find that they speak for themselves. Mr. Lamplugh curtly dismisses the considered opinion of Mr. T. H. Withers, on some cirripede-remains from this bed. Mr. Withers is a leading authority on fossil cirripedes and their evolutionary characters, concerning which Mr. Lamplugh is not qualified to speak. We have complete faith in the opinion of Mr. Withers on this subject.

Again, on p. 15, when referring to a certain mass of clay ascribed by us to the Upper Gault, Mr. Lamplugh's words, "and therefore including this section in the area supposed to be inverted", wrongly introduce an implication that we have never adopted. Once again (p. 8): "Dr. Kitchin and Mr. Pringle record an ammonite of the auritus-group, supposed to be *Hoplites catillus* (J. de C. Sowerby) . . ." (See also p. 78.) We neither ascribed any ammonite seen by us to that species nor referred the species to the *auritus*-group. And, as a further example, on p. 18 Mr. Lamplugh states that we have described and figured "the tailing out southwards" of the Silty beds at the entrance to the Miletree Farm pit. What we actually described and figured was a striking unconformity between Upper Gault and Lower Greensand at the opposite (northward) end of the pit. Although this is the most important feature of the section, it is left unmentioned by Mr. Lamplugh.

Such a mode of representing our views must tend to discredit us unfairly in the eyes of uninformed readers. The same misleading method is too noticeable also in Mr. Lamplugh's presentation of geological facts. For example, on p. 41 he refers to fossils of the Shenley Hill limestone found many years ago by the Geological Survey at Long Crendon, and leads the reader to believe that these came from "calcareous stone" found there below the Gault. In reality there is no particle of evidence for that belief. In the original manuscript record of the section from which the specimens were obtained the presence of Gault is not mentioned. The Gault of that locality is underlain by a Purbeck limestone; but the fossils were stated to have been found just above Portland limestone, which was then worked at its outcrop in openings immediately adjacent to a

Gault clay-pit. It seems clear that Jukes-Browne regarded these specimens with suspicion. Although he was provided with a list of these fossils, which were collected for him, he did not mention them in connexion with his section published in 1900 (reproduced by Mr. Lamplugh). He probably suppressed mention of them, for he certainly knew better than to assign them to a horizon below the Gault Clay. In any case, the lowest Gault of Long Crendon has been shown to be Upper Gault, with an unconformable base, and the *mammillatus*-horizon, to which Mr. Lamplugh wrongly ascribes the limestone, is unrepresented there. We have no doubt that the fossils, all of which may have occurred in a single piece of limestone of small dimensions, came from the surface. Fragments of "red chalk" and other extraneous material have been recorded from the Drift of Oxfordshire. There is Drift on Long Crendon hill: the matrix of these fossils is not unlike "red chalk".

On p. 28 of his paper, when comparing the section in the old pit near Heath House with that in Harris's pit at Shenley Hill, Mr. Lamplugh says that the Gault in these two exposures agrees in all essential particulars, a statement quite contrary to fact. The lowest 15 feet of Gault in these two sections is so well contrasted, both lithologically and palæontologically, as to preclude any idea of correlation. This contrast is fatal to Mr. Lamplugh's view. He also states as a fact that Lower Gault fossils were formerly obtained from the Heath House section (p. 79), though there is no evidence of this. Jukes-Browne recorded *Ammonites interruptus* from a nodule-bed there which contains a rich Upper Gault fauna; but certain hoplitids of the Upper Gault were at that time usually determined as "*A. interruptus*", and the record is without any value. To accept it as evidence of the presence of Lower Gault is merely absurd, in view of the fossils ("*Ammonites rostratus*," "*A. varicosus*," "*Inoceramus sulcatus*" and others) with which the species was stated to be associated.

On p. 20, Mr. Lamplugh's diagram illustrating the section at the northern end of Miletree Farm pit is so drawn as not to show the important unconformity that occurs there. The reader must inevitably obtain a false impression as to the relation between the Gault and the Lower Greensand at that locality. The case is poor indeed that depends on such methods of advocacy as are illustrated by this and the other examples mentioned above.

In his discussions of the palæontology Mr. Lamplugh shows little understanding of essentials. Names seem to appeal to him more than the facts and principles of evolution, about which he appears to know nothing. His method is to labour the points that he believes (not always correctly) to be favourable to his view and to pass adroitly over those that are unfavourable. Speaking of the *Inocerami* found in the lower part of the Gault at Harris's pit (p. 78), believed by him to be Lower Gault, Mr. Lamplugh states that one of these is a form common in the "lower part of the Gault" elsewhere,

specifying Muzzle (West Norfolk) and Specton (p. 51). He is evidently unaware that he is here referring to Upper Gault deposits. The *Inocerami* in question are found at those localities in overlapping Upper Gault, and are not known to occur at any place near the true base of the Gault.

The age of the Gault in Harris's pit can only be determined by means of its fossils; yet the example just cited shows that Mr. Lamplugh is incapable of interpreting the evidence by which alone a true correlation can be made. This statement applies also to his discussion of the ammonites from the lower part of the clay in that pit (pp. 78–9). His remarks show such superficiality and confusion of ideas that they are ridiculous as well as valueless. No informed palæontologist having any regard either for his own reputation or for sound stratigraphy could be persuaded to assign the lower part of the clay at Harris's pit to the Lower Gault, or even to a horizon as low as the basal part of the Upper Gault. A stratigrapher, however, ascribes it without scruple to the Lower Gault, with the benison of the Geological Society of London to support him (1903, 1922).

Mr. Lamplugh's method of dealing with the fauna of the Cenomanian limestone is equally futile. Why trouble to say so much about *Terebrirostra neocomiensis* and *T. arduennensis* when the forms found in the limestone at Shenley Hill are identical with the later, extreme evolutionary types characteristic of a low Cenomanian horizon in France and in this country? Why pass so lightly over *Catopygus columbarius*, *Nucleolites lacunosus*, *Cidaris bowerbanki*, *Rhynchonella grasiana*, *Pecten curvatus*, *Isoarca obesa*, *Cyphonotus incertus*, and other telling species? If, as Mr. Lamplugh believes, *Leymeriella regularis* occurs indigenously in the same bed as these, then the whole basis of zonal palæontology, as practised daily by professionals like ourselves and by innumerable amateurs the world over, is false. But practical results prove that the contrary is the case. The firm foundation upon which accurate stratigraphy has been built is not yet shaken; the method of William Smith is not to be discredited by the assumptions of Mr. Lamplugh.

Mr. Lamplugh also speaks of *Inoceramus concentricus* as coming from the limestone. Whether the limestone be ascribed to the "*mammillatus*-zone" or to a Cenomanian horizon, it is in either case safe to assert that this species does *not* occur in the bed; it may probably have been collected from the basal bed of the Upper Gault, with which the limestone-lenticles are found accidentally associated. Mr. Lamplugh states that the absence of certain species speaks against our view concerning the age of the limestone, apparently unaware that some of these (for instance, *Pecten asper*) are not found at the horizon in Wiltshire with which we correlate that rock.

Mr. Lamplugh's failure to determine correctly the age of the limestone and the clay that overlies it invalidates the whole of his paper. Judging by the above examples of palæontological ineptitude

and the many other errors and fallacies in the paper (we can furnish a long list, if desired), it can only be assumed that before undertaking publication the Council of the Geological Society failed to submit the manuscript to any capable palæontologist familiar with the zones in question.

In the course of the paper we are mentioned by name more than forty times, not always without derogatory implication in the context. It is most unusual to find the *Quarterly Journal* utilized as the medium of publication for a paper of this character, in which the collective effect of the repeated personal references and the misrepresentations is sometimes that of a not well-veiled *argumentum ad hominem*. We have always understood that one of the chief functions of the Publication Committee of the Geological Society is to prevent the publication of matter which may give just cause of offence, and to provide some guarantee to the Fellows that the substance of communications issued by the Society shall be sound in essentials. Apart from any personal considerations, we, as Fellows, regret that the Council has created so questionable a precedent by the publication of Mr. Lamplugh's elaborate and costly paper in the form in which it has appeared.

F. L. Kitchin.
J. Pringle.

THE AGE OF THE SHENLEY LIMESTONE.

Sir,—In February of last year I published a short report on the Echinoids of the now notorious Shenley Limestone lenticles; and in the following month Mr. Lamplugh asked that "judgment in respect of [my] deductions" should be suspended. His "judgment" has now been pronounced and published (*Q.J.G.S.*, lxxviii, pp. 76–7), and I beg leave to exercise the prerogative of comment before sentence is passed.

I wish to say at the outset that I have neither desire nor intention to be drawn into a controversy on matters beyond my own observation—the stratigraphical relations of the Shenley limestone are none of my business—and that I am concerned solely with the facies presented by the Echinoid fauna. It is true that most of the specimens are too poorly preserved for rigorous determination; but it is equally true that a few of them are as satisfactory as could be desired. Is it a coincidence that every one of such specimens indicates an horizon at or above the top of the "Upper Greensand?"

Cidaris bowerbanki was recognized on three (probably six) radioles, and Mr. Lamplugh suggests that "the determination can hardly be reckoned conclusive". With all deference I would submit that in this case the radioles are vastly more distinctive than the test. At least, they belong to a *Tylocidaris* (type *C. clavigera*), and that genus is not known before the Cenomanian. Arguments based on its generic range (after the style adopted by Mr. Lamplugh in his criticism) would make it reasonable to assume that the Shenley

Limestone is of Upper Senonian age! Again, *Nucleolites lacunosus* (an equally confident identification) is airily disposed of with the remark that the *genus* has "many representatives in the Lower Cretaceous". *Nucleolites* (in the sense understood by both of us in this case) ranges from the Bajocian upwards, and I fail to see why the Corallian age of the Shenley Limestone should be disputed if such an argument is to hold! I assume that here, as elsewhere, my critic intends to suggest that I have made a mistake in identification. I should have little cause for complaint if he had stated that opinion outright; but hints and insinuations are unpleasant. Anyhow, the specimens exist, and the truth is in them.

But it is useless to haggle over names—especially when their application by our forefathers is regarded as evidence in modern palæontological stratigraphy. It is difficult to express in antiquated terms the views of palæontologists of to-day; and still more difficult to convince those who consider that a "new genus and species has no present value for correlation" that they are mistaken. Palæontologists will understand me when I say that the whole facies of the Echinoid fauna under discussion suggests a "Warminster Top-Beds" horizon; and that failure to attach a single specific name throughout the list would in no way have detracted from my confidence.

I should like to close on a less controversial note. As a professed palæontologist, I am deeply grateful to Mr. Lamplugh for an innovation in his paper. The idea of printing "field-determinations" of fossils in roman type, reserving italics for those based on special study, seems extremely well-inspired. If generally adopted, the practice will halve the difficulties of those who try to trace ranges as recorded in literature; had it been carried out since 1875, Mr. Lamplugh's criticisms of my list might have been less voluminous and more convincing.

HERBERT L. HAWKINS.

UNIVERSITY COLLEGE, READING.
12th May, 1922.

ANNOUNCEMENTS AND INQUIRIES.

Professor H. L. Hawkins, Geological Department, University College, Reading, would be very grateful to any collectors or curators of local museums who have specimens of *Pygaster* from authentic British localities if they would communicate with him. He is preparing a monograph for the Palæontographical Society, and desires to make it as complete as possible. At the present time he is particularly anxious to see *Pygasters* from the lower Oolites of the Midlands and North of England. While fully prepared to accept specimens as gifts or in exchange, he undertakes to cherish and return all specimens lent on other terms. All such help will be duly acknowledged in the monograph.